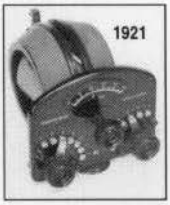
THE ATWATER KENT RADIOS

By Ralph O. Williams

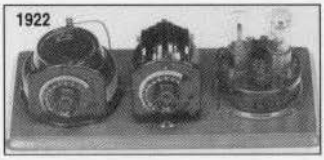








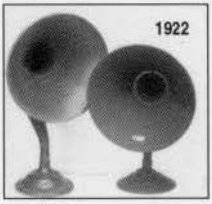




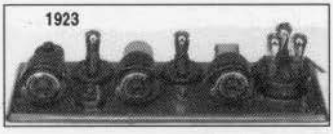




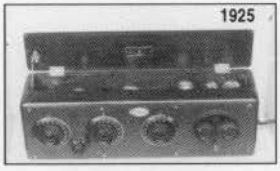
A. ATWATER KENT
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ATWATER KENT MANUFACTURING COMPANY
Philadelphia

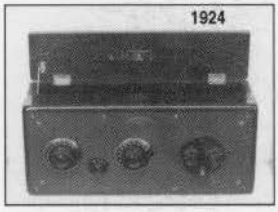












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Volume XII, 1999

THE ATWATER KENT RADIOS

by

Ralph O. Williams

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THE COVER

The cover consists of a pen and ink rendering of A. Atwater Kent, taken from advertising literature, surrounded by representative samples of his radio products, the subject of this book. These range from the early instruments in 1921 to the end of production in 1935. More information on the cover photos can be found in the book.

PHOTO CREDITS

All photos were taken by the author and by Alan Douglas. Those by the latter are so marked.

THE ATWATER KENT RADIOS

by Ralph O. Williams, N3VT
Orient, NY

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FOREWORD

One of the giants of American industry, by any standard, was Arthur Atwater Kent, who, in the brief span of fourteen years, designed, manufactured, marketed and sold some five million radios. While he became exceedingly wealthy in the process, he in turn bequeathed to us a legacy of a myriad of unique products of high quality. These products of his energy and invention are the topic of this book.

Our author, Ralph Williams of Orient, NY, has spent a large part of his adult life studying Atwater Kent, his methods, and his radios, and is widely recognized as the world expert on the subject. Since his retirement from industry, he has founded a private museum, one of the most complete in the world, devoted to the man and his radios. The results of this dedication also have appeared through the years in various writings, including a brief series in the *AWA Review,* Volumes 1, 2, and 3, published in 1986, 1987, and 1988, and another in Volume 10, in 1996. Other journals, such as *Radio Age,* have also published his material, which has proven to be very popular with collectors. Unfortunately, with the possible exception of the 1996 material, all these are now out of print, and cannot be obtained except through private sources.

The sheer quantity of material in this volume of the *AWA Review* has necessitated a much larger publication than usual, but we hope you will agree that the results have been worth the effort. To assemble the details and present them in a coherent, progressive manner has been a monumental job on the part of our author, and has been several years in preparation. It is also a fascinating example of how a radio historian can derive a complete picture of past events by piecing together seemingly unrelated clues.

We emphasize that this book is not simply a reprint of prior writings, but is a complete new work, covering the gamut from the first Atwater Kent lab instruments to the sophisticated superhets. Details of many of the sets, not previously printed, are included. While not all the pictures from prior work are reproduced here, the book still boasts over one hundred illustrations. In addition, our author has discoursed on the changing face of the radio art and the socioeconomic climate of the 1920s and 1930s, which provided the challenges so important to the success of Atwater Kent. We have also included a separate chart detailing the radios and their characteristics.

Comprehensive collections of Atwater Kent radios are not too plentiful, but the beginning collector, armed with this book as a guide, can still find a wealth of subject material to work with. For the more experienced, the information herein can help clear the confusion surrounding the minor differences in the products as they developed. Hopefully this book will help focus attention on this remarkable man and his contributions, and perhaps stimulate all collectors to new efforts.

The Antique Wireless Association takes pride in presenting this book.

The Editor

INTRODUCTION

Atwater Kent radio receivers attract substantial attention and interest from present-day radio collectors and historians. While the radios themselves can be fascinating, their development is even richer in history and technology. A single radio, when carefully examined and analyzed, is a source of information about the state of the technical art at the time of its manufacture. But a series of radios, especially if they follow each other as members of a family, tell much more about the growth of the radio art and the evolution of its technology.

From the 1920s onward electrical-device-manufacturing companies pioneered an entirely new industry. It combined the complex technology of high-frequency electrical engineering with the manufacturing techniques used to make electrical machines and with the methods of mass production to turn out products that were state-of-the-art in the new field of entertainment radio. The nature of the new business included the novel idea that product improvement was as important as performance, and that new models sold as quickly as they could replace their immediate predecessors.

An opportunity to analyze this process offers much toward understanding American industrial development and production. This review looks at the work of one manufacturer, Atwater Kent, from the beginning of radio parts production in 1922 to the end of the business in 1936. Atwater Kent's radio production started as little more than an extension of his automotive-electric manufacturing capability. His radio business grew rapidly and by the mid-twenties had displaced the production of automotive-electric products. When his radio production peaked in 1928, Atwater Kent had become the world's largest maker of radio receivers, and by 1929 his factory was the most modern radio-production facility in the industry.

This book is a series of descriptions and discussions of the radios in the Atwater Kent product line. Its purpose is to use the developing radios to look at the changing technology and at the maturing of small-product assembly line practice. It starts with the Atwater Kent radio instruments which preceded the manufacture of complete radios. Then it analyzes the Open Sets and the mahogany-box receivers. Next, the metal-box sets are covered, and finally the table compacts and the floor models that were produced in the 1930s are examined.

Atwater Kent's entry into radio manufacturing was based upon a nearly ideal matching of company capability to the specific needs of the

emerging radio art. There were two aspects of this opportunity. First, at the time of Atwater Kent's entry into radio, late 1920 for design and early 1921 for beginning production, he had a nationwide organization of service shops and dealers in place across the United States. They were in the automotive-electrical business, handling a fine product line. They provided both sales and the service for ignition, starting and generating systems and were ready for a new line of related equipment. The dealers and service people were not well suited to wireless technology but were well versed in handling automotive customers, and therefore the potential amateur/hobby and home radio-parts buyers.

The second aspect was that the Atwater Kent factory regularly used its specialized machinery to make electrical parts and had the design skills that were needed to produce radio instruments. The production and the engineering departments were well aware of the uncommon fabrication processes for winding coils, insulating for high voltage, and making fixed-value condensers. They only needed knowledge about the special considerations related to high-frequency applications. The superb workmanship that characterized Atwater Kent automotive-electrical parts was ready for making the phenolic castings and turning out the brass and steel hardware and winding the coils for radio instruments such as variometers and transformers.

Atwater Kent's factory was, therefore, well suited to meeting the requirements of this newly developing radio market. He and his staff had the technology, the manufacturing expertise, the business acumen and the vision to see the potential rewards. While there are no surviving records to document how Atwater Kent entered the new market, the artifacts reveal that getting into the radio business was done on a progressive basis.

Chapter 1

RADIO INSTRUMENTS AND MOUNTING BOARDS

THE RADIO INSTRUMENTS

The point of entry was the design and distribution of radio instruments, not complete radios. Careful analysis of instrument part numbers and contemporary advertisements indicates that the factory started its production of radio instruments toward the end of 1921. With an active distribution system in place for the automotive-electrical product line, reaching potential radio customers must have been relatively easy.

Based on the factory capability and the needs of the radio market, it appears that the first two radio instruments offered for general sale were the Nine-to-One audio transformer No. 3509 and the Unmounted Variometer, No. 3488, shown in Figure 1A. The Variometer was made up of four separate coils, two of which were fixed with the other two making up a rotatable ball. All four coils were connected in series. Electrical access to the inner (rotatable) coils was via solder attachment to the two halves of the shaft, which extended inside the ball and were insulated from each other by means of a tiny disk and an over-riding sleeve.

The inner and the outer coils were magnetically coupled. This permitted variation of the inductance over a wide range by rotation of the ball. In addition, the proximity of the inner coil to the outer coil provided sufficient capacity to resonate the inductance within the frequency range of the broadcast band. When fully aligned in one direction, both the inductance and the capacity were at maximum. The self-resonant frequency for that condition was a little lower than 700 kHz. Fully aligned in the other direction, the self-resonant frequency was 1.4 MHz. At about 90 degrees relative rotation, the resonant frequency was about 1 MHz. Any circuit capacity, including that of the tube, lowered those resonances.

At very nearly the same time as the No. 3488 Unmounted Variometer was designed, work was done on another radio-frequency instrument, the Unmounted Variocoupler No. 3529, Figure 1B. It was another variable inductor, differing from the Variometer in providing a means of tapping the outer coil. Mechanically, the two had similar rotors, but the fixed coils on the Variocoupler were wound on the outside of the coil forms

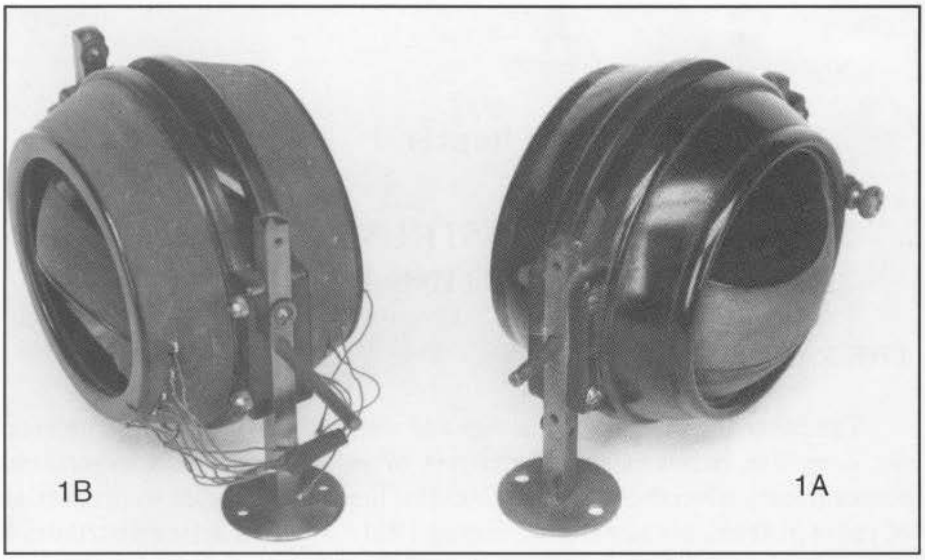


Figure 1A. *(above right) Unmounted Variometer. Kent's first instruments were inductors, built to be used with a vertical panel.*
Figure 1B. *(above left) Unmounted Variocoupler. The taps were to be soldered to switch points mounted in the radio's panel.*

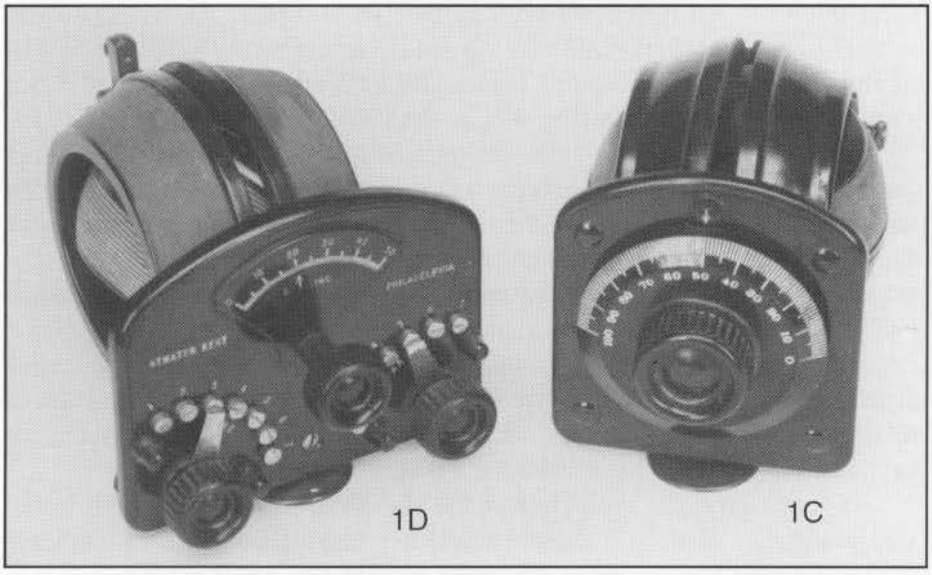


Figure 1C. (above right) *Mounted Variometer. Kent decided to make his instruments independent of a front panel.*
Figure 1D. (above left) *Mounted Variocoupler. This instrument and the Variometer pointed the way to the Open Set that was Kent's Hallmark.*

instead of inside as on the Variometer. The circuit functions of the two instruments were quite different. The Variometer was used as a resonator in grid or plate circuits to provide a high impedance for tuning or load control. The Variocoupler was intended to provide signal transfer from an antenna to the receiver's input circuit and therefore acted as a tunable, impedance-matching transformer.

When the Variometer and Variocoupler were initially introduced, they did not have front panels. They were offered for behind-the-panel use in a constructor's set. Individual panels for these two instruments were available separately in both brown and black Bakelite. Later, the instruments were supplied with panels, when they were identified as the Mounted Variometer, No. 3714 and the Mounted Variocoupler, No. 3731. These are shown for comparison and identification in Figure 1, C&D.

The part number assigned to the Unmounted Variometer, No. 3488, reflects the overall identification system used in the factory. All parts, from screws and washers to complete assemblies, including radio sets, were given part numbers. The numbers assigned to radio parts were a continuation of those used for the automotive-electrical parts that were produced at the same time and earlier. Where a part used in the assembly of a radio instrument was identical to that used in an earlier electrical assembly, the original part number was continued. An example is the No. 1068 staple used on the underside of breadboards. It was originally used in ignition-coil boxes.

Sequential assignment of part numbers provides the means of dating the very early Atwater Kent radio instruments. Part numbers above No. 3400 tended to be radio parts. Initial assignment of these numbers seems to have occurred in late 1921. As new instruments were designed and produced, they were given new numbers. If the instrument required parts not available from earlier designs, the new parts were assigned numbers in sequence with the numbers of the instruments. A reconstruction of part number assignments indicates that about 600 new numbers per year were assigned starting in early 1922 and continuing through the breadboard era.

The construction of the Variometer required the extension of three manufacturing processes that had been long established in the Atwater Kent factory; phenolic casting, brass-part fabrication, and coil formation. New dies for the casting and new mandrels for forming the coils were needed, but they were not different in technology from those used in earlier products. The brass parts were simple variations of hardware that the factory produced in making automotive-electric equipment. The differences came from the electrical design-function where new and unfamiliar test equipment was required to establish the radio-frequency parameters of the inductor.

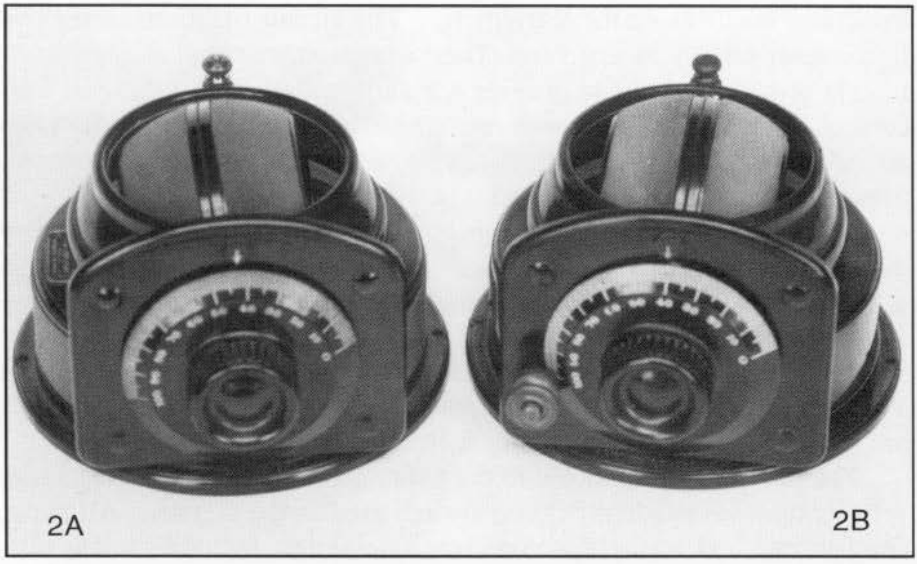


Figure 2A. (above left) *Coupled Circuit Tuner. The outside coil was used to couple an antenna to a circuit which was tuned to the incoming frequency by the other two coils.*
Figure 2B. (above right) *Type 11 Tuner. This instrument was the Variometer turned on its side. They were electrically identical.*

The next variable inductor produced by Atwater Kent was the Coupled Circuit Tuner, No. 3752. It is shown in Figure 2A. This instrument, like the Variocoupler, provided a means to match antenna impedance, usually low, to the detector-input impedance, which was high. Antenna matching was crude since the primary coil of the tuner had only three taps. The Coupled Circuit Tuner also provided a small amount of selectivity since the ball and the inner coil of the instrument were self-resonant in the band around 400 meters, where most of the broadcast stations were located. The instrument was essentially a variometer around which another coil was wound. Mechanically, it was the Variometer turned on its side with one of the Variometer's fixed coils enclosed in a part of the base. Another coil for the antenna circuit was wound around the outer periphery of the base.

The Coupled Circuit Tuner was therefore made up of five coils, four being identical to the Variometer, with the fifth coil wound on the outside of the instrument body and tapped at three places along the winding. The taps were brought out to binding posts on the rear apron of the base. The Coupled Circuit Tuner combined the functions of the Variometer and the Variocoupler. It provided a means of matching to various antennas via the taps while it also provided a resonant tuning circuit using the independently connected ball and fixed spherical coils.

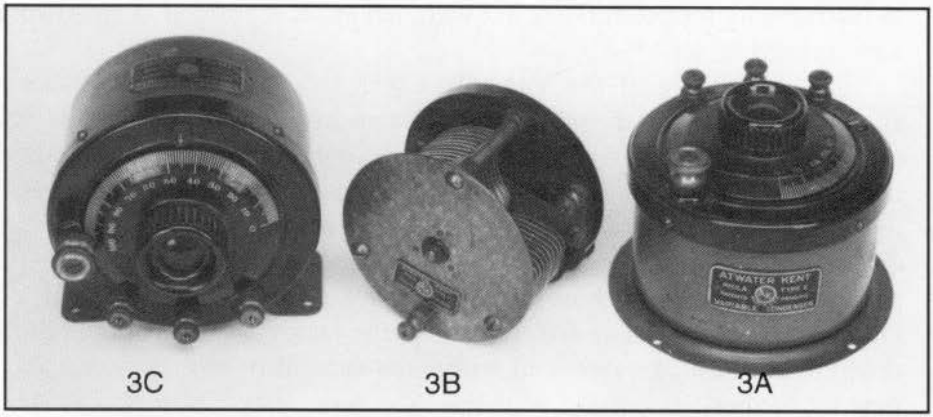


Figure 3A. (above right) *Condenser, Vertical. This condenser was intended for board mounting. The instrument inside the can was the same as that in Figure 3B.*
Figure 3B. (above center) *Condenser, Panel. This condenser was sold as a companion to the panel-mount inductors (1A, B). Note the decorative pattern of engine-turnings on its frame.*
Figure 3C. (above left) *Condenser, Horizontal. This instrument was used for independent board mounting. It was the design basis for all the subsequent board tuning condensers.*

The fourth variable inductor was called the Type-11 Tuner, Part No. 4051, shown as Figure 2B. It was electrically identical to the Variometer. Mechanically, the unit was identical to the Coupled Circuit Tuner without its outside base coil. In addition, a condenser was incorporated in the instrument connected between the upper fixed coil binding post and the antenna binding post on the rear apron. The Type-11 Tuner was offered to the general public in early 1923, based on the dating scheme, for use in the antenna circuit of a receiver. Short antennas were to be connected to the upper binding post where the grid circuit was also connected. Long antennas were to be connected to the antenna terminal on the rear apron. The internal condenser of approximately 50 picofarads provided the compensation for a long antenna that was needed to satisfactorily tune the grid circuit of a detector or radio-frequency amplifier.

Another way to secure selectivity over a band of frequencies was to use a variable condenser to resonate a fixed coil. Kent produced Variable Condensers for this purpose in three forms. The first, Figure 3A, was a TA vertical-shaft condenser enclosed in a drawn-metal can and topped with a Bakelite panel. (TA was used to designate Table or board mount.) It was designated Part No. 4117. The second form of the Variable Condenser, No. 4165, Figure 3B, was to be panel-mounted. It did not have an enclosure but instead was sold with a dress-panel and a dial. It was equipped with binding posts for external connection. These two condensers were offered

as instruments for general use but were never incorporated in an Atwater Kent receiving set.

The third form of the Variable Condenser was made available at about the time the earliest Atwater Kent receivers were produced. This tuning device, No. 4270, Figure 3C, was also a stand-up or table-mounted instrument but incorporating a horizontal shaft. The electrical parts of the condenser were enclosed in a drawn-steel container with a panel and dial on the front of the assembly. The drawn can was very similar in shape and diameter to those used on the Two Tube Amplifier (analyzed later in this review). The difference, for the factory, was the depth of the draw, about 30%, a value well within the capability of the presses and a new set of dies.

The Bakelite panels that were parts of these condensers were further examples of the way Kent's factory could produce attractive and practical instrument parts for many different applications. Different but equally characteristic Bakelite panels and fixtures were basic parts of the amplifier instruments described in the next section of this review. These brown Bakelite faces became and remained the hallmark of Atwater Kent instruments throughout the early period of his production, for both the separate instruments and the assembled receivers.

The coil that was first used with the horizontal-shaft condenser in an Atwater Kent receiver was identified as the Radio Frequency Transformer, No. 4326. It was the predecessor to all the Open Set coils used in Models 9, 10 and 12 series, but was first used on the Model 8. The body of the coil was cast in Bakelite and wound with cotton-covered copper wire. It had a vertical axis, was table-mounted and had four binding posts on its top. It also had a label, which identified it as "Radiodyne," fastened to the top with escutcheon pins.

Atwater Kent packed the inductive instruments and the variable condenser units in cardboard boxes with pictures of the enclosed instruments on the box faces. Into the box the factory also provided data on the application and connection of the parts explaining how they were to be used in complete radio receivers. Also included was catalog material about the other instruments the factory offered.

THE MOUNTING BOARDS

When Atwater Kent began producing radios instead of instruments alone, he combined his quality of manufacture with the predominant style. His instruments were individually equipped with attractive sub-panels and dials and were to be mounted on a flat table-like surface. Therefore, along with the instruments, he produced boards on which the instruments could be assembled. If the factory part numbers were assigned

in time sequence, they indicate the boards were offered for sale shortly after the first instruments, and months before the radio assembly in the factory was initiated. The first board was No. 3601, 8½ by 18 inches; it was released about the middle of 1922.

Significantly, the boards were of highest quality, finished with the molded-ogee curve on all four edges and with tongue-and-grooved end-pieces to prevent warping and checking. That style, which was continued for as long as Open Sets were made, is one of the main attractions for present-day collectors.

When requests made by the Atwater Kent distributors for assembled sets convinced the factory to offer complete radios, it was typical of Atwater Kent to simply put together the instruments and the boards that he had been producing. The acceptance of the resulting radios encouraged the factory to continue with development of circuits and performance, but to retain the characteristic Open Set style. They were produced for about three years, a long time in the rapidly changing conditions of the early twenties.

From the beginning, Open Set boards were made of solid mahogany with a varnish finish. While it is possible they were available in different shades of brown, no record of different board materials or colors exists. Collectors occasionally discuss how dark the original color was in comparison to the color as the board is found today. While some like a medium brown, the removal of the TA unit from a board that has never been refinished and which has not been hurt by the passage of time, shows a rich brown with a highly-polished finish.

Atwater Kent used wire staples made of steel and coated with copper to secure the wiring on the breadboards. They, too, were carried over from the ignition business where they were used to secure some of the wires inside the wooden boxes that contained the high-voltage transformers (ignition coils).

Two more mounting boards were offered, one early and one later. The early one was No. 3795, 8½ by 24½ inches. The later one was No. 4056, 8½ by 26½ inches. All three of these boards were used by dealers to assemble sets and were also sold to radio constructors for their own set construction. When the factory started to assemble sets for sale as complete radios, a major revision of the production floor layout was needed. The wood shop had to be expanded. Production of the wooden boxes that were used to house ignition coils continued and some sales of individual boards took place. The big impact came, however, from the popularity of the Open Set.

Chapter 2

AMPLIFYING INSTRUMENTS

At the same time that Atwater Kent worked on the radio-frequency instruments, he was getting started on the second group, the audio-frequency instruments. Although Kent's entry into the radio market started with component parts, his intentions were focused on complete radios. His early plans were based on the experimental and amateur nature of the radio business. They were developmental rather than definite. Early on, he centered on the use of vacuum tubes as detectors and amplifiers in audio-frequency circuits. Although his first product was the Variometer, the second electrical instrument that Atwater Kent produced was an audio transformer, No. 3509, shown in Figure 4A. It was to be used in audio amplifiers.

This transformer required less change in factory processes than the radio-frequency instruments. It was essentially an ignition coil with different specific windings for its primary and secondary. The core was punched out of thin steel sheets by the same process that was used to make armature laminations for some of the motors and generators that the factory was building. The top and bottom of the enclosure were similar to the pieces used on ignition coils and were formed by similar stamping dies. The binding posts were re-orders of those used elsewhere in production. Altogether, the transformer was a minor extension of the earlier product line.

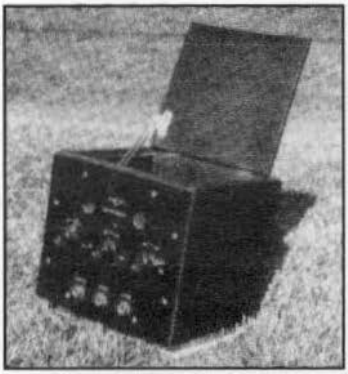


Figure 4A. *Audio Transformer, Type F. Kent's experience with cores and coils used in ignition systems enabled him to offer this instrument as one of his first.*

The proper name for this instrument was the "Nine to One Ratio Transformer". As its name indicates, the turns-ratio of secondary to primary was nine to one. The frequency response was stated to be from

about 100 to 8000 Hz. This range exceeded most other high-ratio transformers of the time and illustrates the intention and expected capability of the Atwater Kent factory to produce high-quality instruments that were as good as, or better than, contemporary manufacturers. However the range also exceeded the capability of reproducers, and consequently this transformer was not carried forward into Kent's line of radios.

A very big shift occurred in the direction that the new production was going in the middle of 1922 when Atwater Kent decided to penetrate the radio market by producing an assembled amplifier. Here, his engineering people had to cope with the characteristics of signal conditioning and amplification as well as component assembly. The device they built was the very rare detector-two-stage audio amplifier in a wooden box, No. 3590, Figure 5 A&B. It was ten inches wide, seven inches high and seven inches deep with a hinged cover. Inside were two No. 3509 transformers and three tubes, two type-201 and one type-200. Connections to the unit were made using binding posts inside the box with wires running



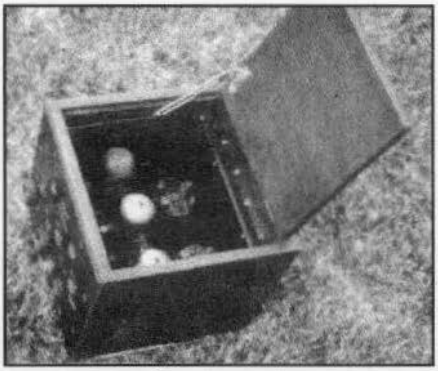


Figure 5A. (above left) *Detector, Two Stage Amplifier, front. Kent assembled two type-F transformers and panel rheostats in a wooden box derived from his automotive-electric parts business.*
Figure 5B. (above right) *Detector, Two Stage Amplifier, top. The tube sockets were not made by Kent. His came a year later, and used brass locking cylinders instead of cast Bakelite.*

through holes in the back. The front of the box was a Bakelite panel with screened observation holes.

Adjusting the filaments of the tubes required another new instrument, the Panel Mounted Rheostat, No. 3530. It is shown in Figure 4B, together with the Table Mounted Rheostat, No. 3668, Figure 4C. These units required the factory to learn another process; the reliable connection of nichrome wire to other metals, including brass and steel.

The new No. 3590 detector-amplifier was not made entirely of Atwater Kent parts. It used tube sockets of another brand. (A quick examination of the unit did not reveal the name of the maker.) The first of Kent's

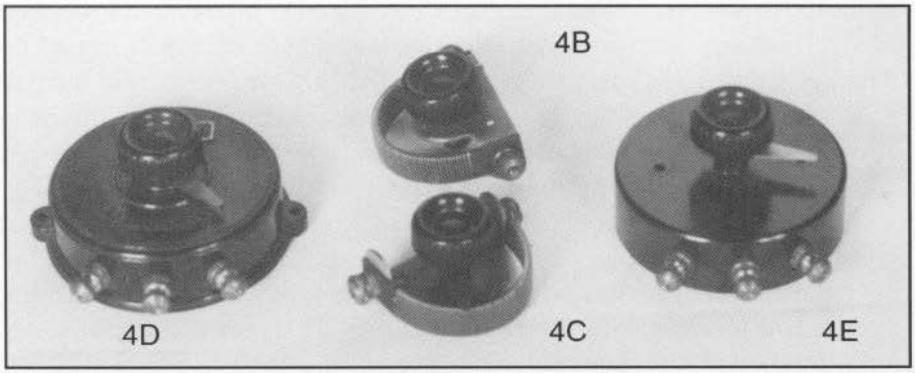


Figure 4B. (above, center, top) *Panel Mounted Rheostat. Control of filament current was necessary for tube operation. This device had to be designed and sold as soon as Kent entered the radio business.*
Figure 4C. (above, center, bottom) Table-*Mounted Rheostat. This instrument is the same as the panel rheostat, but attached to the board instead of the panel of a radio.*
Figure 4D. (above, left) 4E. (above, right) *Potentiometers, Table and Panel. Finer control of amplifier tubes required a device to provide variable grid bias. These units tapped the filament voltage for bias.*

sockets came as integral parts of his amplifying instruments, including the table mounted (TA) detectors and amplifiers.

Before he started building complete radio receivers, but after the wooden-box detector-amplifier, Kent put four amplifying instruments and three detectors on the market. He also sold four different tube units and sockets. In addition, there were several styles of potentiometers, a second audio transformer and two fixed-tune radio-frequency transformers. All of these instruments were designed in his plant, in part based on his engineers' technical experience with auto-electrical devices, and in part based on their learning about radio technology. The electrical design was not difficult, but Kent's mechanical design was a major departure from the general practice of the day. Where other manufacturers tended to assemble small components in a manner similar to Kent's work with the No. 3590 wooden box, Kent aimed at as much integration as the immediate state-of-the-art would permit. Two techniques had to be perfected, drawing metal cans and producing dies for casting Bakelite. Kent's success with these processes in the automotive-electrical business was the key to his continuing growth.

DETECTORS

A radio set in the early days had to do more than simply amplify radio signals. It also had to convert them into electrical currents which headphones or a loudspeaker changed into sound. The converter from

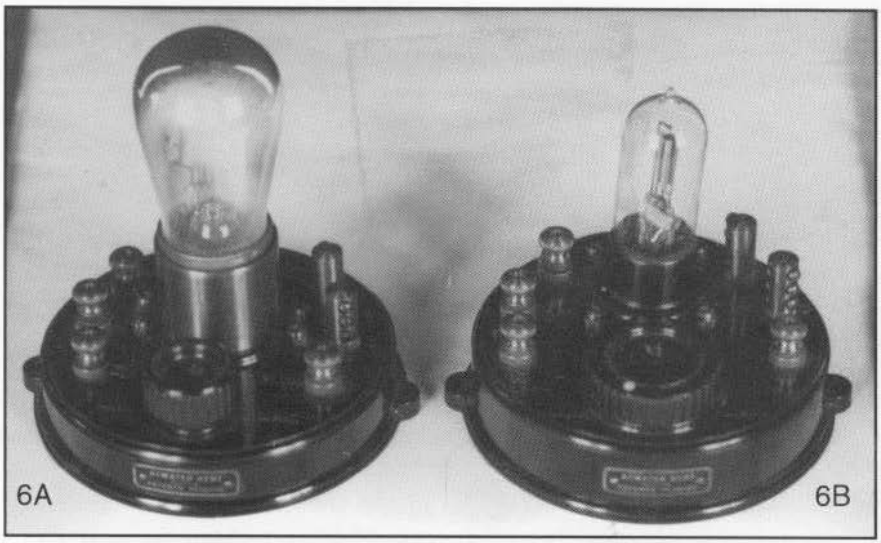


Figure 6A. (above, left) *Detector, used with type-200 tube. Kent's board style needed a way to mount tubes. He chose the large cast base with an internal rheostat, grid leak, and condenser.*
Figure 6B. (above, right) *Detector, for use with WD-11 tube. Radio constructors used both Westinghouse and GE tubes so Kent produced Detectors for both styles.*

radio to audio signals was called the detector. Atwater Kent sold two detectors for use with tubes of the time. Part No. 3902, Figure 6A, was for use with the type-200 tube, and Part No. 4053. Figure 6B was to be used with the type-WD-11 tube. These units were Bakelite castings equipped with knurled binding posts and terminals and containing circuit parts below their top decks. They were fastened to a board with screws through lugs in their peripheries.

SOCKETS

To provide the experimenter or early radio enthusiast with a means of safely supporting and connecting his vacuum tubes, Atwater Kent offered several tube sockets. They were available in two styles, with or without a filament rheostat. The earliest was No. 3892, Figure 7A, a Bakelite plug-in unit for 1½-volt tubes that did not incorporate a rheostat. At the same time he introduced No. 3893, Figure 7B, for 5-volt tubes. The first version of this socket incorporated a brass bayonet shell that was painted green. Very shortly after its introduction, the company realized that the unit was drab and needlessly expensive. A polished shell added much to the appearance of the tube socket and actually reduced the cost, so almost all of the single-tube sockets without rheostats that have survived have polished brass shells.

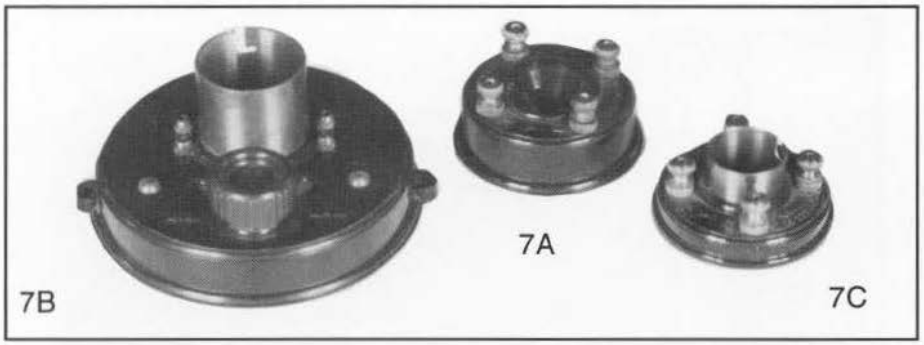
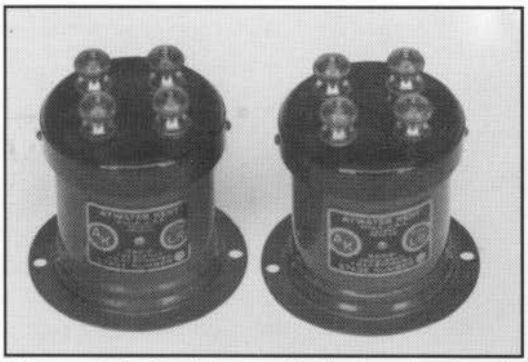


Figure 7A (above, center) **7B** (above, left) **7C** (above, right). *Sockets for 1½, 5- and 3.3-volt tubes. Kent sold these sockets for general use. The 5-volt socket was used on Model 10C but the others were not used on Atwater Kent sets.*

The other tube-socket style included a rheostat for immediate control of the filament current. It closely resembled the detector unit and was identified as No. 4024, Figure 7B. It was made available for general sales at about the same time as Atwater Kent started assembling complete sets and was used on radios in the 4000 series of Open Sets for the radio amplifiers. The last separate socket was No. 4310, Figure 7C, designed to handle type-UV199 tubes.

RADIO-FREQUENCY AMPLIFIERS

A practical vacuum-tube RF amplifier requires a relatively high-impedance instrument to be connected in its plate circuit. It must be of such a value as to cause the tube to perform effectively at a particular frequency. The use of RF amplifiers to select one station from others that transmitted on frequencies near that of the desired station was accomplished by using resonant tuning instruments. In receiving-set applications, the RF amplifiers were voltage rather than power amplifiers. (RF power amplifiers were used for transmitters and were not of a business interest to Atwater Kent.) The impedance of a grid was high and provided a satisfactory load to a preceding plate, except for the substantial difference in required dc potentials. Kent's engineers chose transformers to separate the potentials while maintaining the impedance relationships. Before frequency selectivity had become a critical requirement for RF amplifiers that were used for broadcast receivers, a fixed-tuned transformer operating at the frequency band of incoming signals provided the circuit isolation and coupling that was needed. The Stage 1 Radio Frequency Transformer, Part No. 3802, Figure 8A, was the first of these Atwater Kent instruments. Details about this transformer are given in the segment about the Model 6, No. 4052 Open Set. For general sale a second transformer was offered. It was identified as Stage 2, Part No. 3972, Figure 8B.



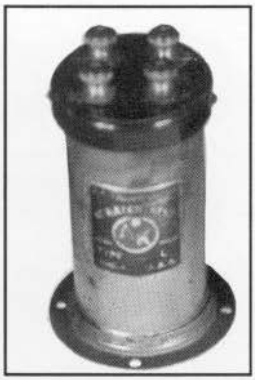


Figure 8A, 8B (above, left). *Radio Transformers, Stages 1 and 2. Early radio amplifiers were not used to tune in stations. They were fixed frequency and very broad. They were used in Models 6 and 7.*
Figure 8C (above, right). *Audio Transformer, Type L. For general use, the Type-L transformer with a 3:1 voltage ratio was better suited than the Type-F with a 9:1 ratio.*

AUDIO-FREQUENCY AMPLIFIERS

In the early twenties, to build up signals, one device was commonly used to couple into and between the grids and plates of vacuum tubes. It was the audio transformer. Other instruments were known, including resistance and impedance couplers, but they had electrical disadvantages, chiefly no step-up ratio. Kent chose the transformer, partly because of all the instruments needed in the radio art by broadcast listeners and others, the one most suited for direct application of his technical and manufacturing capability was the audio transformer. It was in many ways identical to the ignition coils that he made immediately after World War I. Both used two coils of many turns wound around an iron core and enclosed in a metal container. More important, the inductance of the coils, and the frequency content of the impulses handled by them, were in the same frequency ranges for both the ignition coils and the audio transformers.

The differences were to be found in the voltage and current-handling capabilities. The primary of the ignition coils was sized for currents of several amperes whereas the audio-transformer primary was not expected to carry more than 50 milliamperes. The secondary of the ignition coil was insulated to withstand several thousand volts, whereas the coils of the audio transformer did not need insulation for more than three or four hundred volts. Such differences were easily accommodated in the designs of the new product line.

The second audio transformer in the Atwater Kent line was the type-L, Part No. 3775, Figure 8C. Its case was a drawn-steel cylinder about four inches long, relating very closely to the ignition coils being produced



Figure 9A. *Two Stage AF Amplifier. Kent's concept included the potted, table-mounted components as well as the Open Board to carry them.*

at the same time. The case was topped by the same Bakelite terminal block that was used on the radio-frequency transformers.

The next unit designed for audio amplification was not a simple instrument. Instead, it was a complete amplifier of two audio stages, called the 2 Stage AF Amplifier, No. 3634, Figure 9A. It consisted of a table-mounted metal can, about five inches in diameter, which contained the two audio transformers and a Condensite (Bakelite) cover incorporating the tube sockets and the input and output terminals. The input circuit was the primary of the first audio transformer. Its secondary was connected to the grid of the first amplifier tube, a type 201. The plate of that tube was connected to the primary of the second audio transformer, and the second transformer's secondary was connected to the grid of the second amplifier tube, another type 201.

The output of the 2 Stage AF Amplifier was intended to operate a loudspeaker, but could have been used with headphones. Therefore the output terminals were connected to the plate circuit of the second amplifier tube so that the loud speaker or phones could be its plate load. The 2 Stage AF Amplifier was also useful for general-purpose work. It was not limited to radio-set applications. This made it very effective as an auxiliary amplifier in distributing and amplifying audio signals for telephone and public address work.

DETECTOR AMPLIFIERS

The detector was often used along with the first audio amplifier and it was in that form that it was offered by Atwater Kent for general use.



Figure 9B. *Detector, One Stage Amplifier. For those radio fans who did not want to build a set from parts, Kent supplied fully-assembled components.*

The instrument was the TA Detector, 1 Stage AF Amplifier, No. 3676, Figure 9B. The major external differences between this unit and the 2 Stage AF Amplifier were the nameplates and the terminals around the rear part of the cover. The major internal difference was functional. The first tube was a detector, in this case a type 200. The second tube was a type 201 used as an audio amplifier. Only one transformer was included in the Detector 1 Stage AF Amplifier, connected between the plate of the detector and the grid of the audio amplifier. The overall amplification from the detector through the output did not provide a signal level high enough to adequately operate a loudspeaker unless the input radio-frequency signal was very strong.

The Detector, 1 Stage AF Amplifier was not a general-purpose device. Its function was limited to radio applications. The action of this instrument took place as a result of non-linear amplification in the first tube. A signal, appearing at the first grid, caused a minute amount of grid current to leak through a resistor (grid leak) connected from grid to filament. A small condenser also connected from grid to filament was charged negatively by the drop across the grid leak. The condenser and resistor sizes were chosen to maintain the negative voltage for a period that was long compared to that of a radio wave in the broadcast band, but short compared to the period of the highest audio frequency used to modulate the radio wave. The selected values were 250 picofarads for the condenser and 3 megohms for the resistor.

The audio transformer (similar to the No. 3775 transformer and described earlier) interconnecting the two tubes did not respond to the radio-frequency currents because they were beyond its frequency range.

Instead, a plate-bypass condenser around the AF transformer was incorporated in the instrument to provide a return path to ground for the RF part of the plate current. The audio transformer responded to the modulating frequencies (in the voice and music range) and thereby provided an audio wave that reasonably represented the original studio signal. In turn, the second tube amplified this audio signal, increasing its amplitude sufficiently to provide adequate headphone level for all but weak signals.



Figure 9C. *Detector, Two Stage Amplifier. This instrument could convert a moderate radio signal to loudspeaker volume. It was the most common table instrument made by Kent.*

The Detector 1 Stage AF Amplifier was arranged to permit its use by the purchaser as a regenerative detector. To accomplish regeneration in any stage, some of the output must be introduced back into the input of the amplifier. The resonant circuit used to tune the grid in a radio-frequency amplifier was a good impedance for regenerative action in so far as the grid was concerned. For the plate, connection to an external circuit was necessary, so Kent brought the detector plate circuit out on two terminals marked TIC at the rear of the Detector 1 Stage AF Amplifier. This marking was short for "tickler," the name of one form of the regenerative circuit. A circuit suitable for accomplishing regeneration was the connection of a Variometer to the TIC terminals. At some rotational setting the Variometer provided a suitable plate impedance for the occurrence of regeneration.

Another instrument, the Detector 2 Stage AF Amplifier, No. 3812, is shown in Figure 9C. Its general construction was very similar to the Detector 1 Stage AF and the Two Stage Amplifier. The diameter of the top was 5½ inches, large enough to conveniently carry the three tubes, one type-200, and two type-20ls. All three early TA units were built to use tungsten-filament tubes, and the filament resistors in all the early TA instruments were sized to handle the one-ampere current drawn by types-200 and 201 tubes.



Figure 9D. *One Stage AF Amplifier. Before a standard receiver configuration had become popular, this unit filled the gap for fans who needed a little louder output.*

OTHER INSTRUMENTS

Atwater Kent produced one more TA instrument, the 1 Stage AF Amplifier, No. 4030, Figure 9D. Using the sequence of part numbers to determine when it might have been introduced, the nearly four-hundred-number difference from the 2 Stage Audio Amplifier suggests that it came out in late 1922 or very early 1923. A copy of Atwater Kent's listing of instruments, Form 19, published in March, 1923, lists the 1 Stage AF Amplifier, confirming its introduction shortly before that time. The instrument had only one tube, a type-201 whose grid was connected to the secondary of the input audio transformer. The primary was accessed by the input binding posts of the amplifier instrument. Like the other TA units, the output was also accessed by terminals on the top of the Bakelite panel. The 1 Stage AF Amplifier could have been used as an inter stage amplifier or as an output amplifier depending on the choices made by individual constructors. It was never incorporated in a complete radio set produced by Atwater Kent.

Because the TA Amplifiers were intended for use with a loudspeaker, they were arranged with large output terminals containing multiple holes with knurled tightening screws to secure the phone tips that were used on loudspeaker cables and headphones. Functionally, these connected the speaker in series with the plate circuit of the output tube. Although TA Amplifier instruments could be used to power several sets of earphones, the matching conditions for power transfer from the output tube were

poorly met. The headphones of the time were highly developed and sensitive enough that the mismatch was of no consequence. With the lower impedance of loud speakers, particularly the moving-armature style, the output tube tended to act more effectively in delivering power to the speaker.

Nevertheless, a small signal was not expected to fill a room with loudspeaker volume unless the background sounds were reduced far below today's experience. In the days when Atwater Kent instruments were new, a radio was so novel, so uncommon, and so expensive in both money and time that it was accorded the quietness of surroundings that made hearing by a group possible, even with the limited volume available.

Another instrument was used to provide the optimum operating conditions for the early vacuum tubes used in radio receivers. It was the potentiometer, whose function was to provide a variable bias to the grid circuit. It was usually connected across the grid circuit of an RF amplifier. By adjusting for just the right amount of bias, an RF amplifier could be operated just below the point where it became unstable, because of its tendency to regenerate. Atwater Kent produced the potentiometer in several forms. The table-mounted instrument was No. 3978, Figure 4D (page 18), and the panel instrument was No. 4095, Figure 4E. Both incorporated cards around which about 600 ohms of resistance wire was wound. A rotor was arranged to push a contact against the card as its shaft was turned.

Two manufacturing techniques distinguished these Atwater Kent instruments. One was the factory's outstanding Bakelite casting capability and the other was their use of drawn-steel containers for housing the instruments. Increasingly, through the time that Kent made radios, he implemented his designs by the use of shaped steel. The degree of deep drawing, evidenced by the Type-L audio transformer (in the right foreground of Figure 8C) demonstrates Atwater Kent's mastery of the art of shaping steel.

Atwater Kent made his instruments available through radio-parts sales companies and through his automobile-ignition and electrical-equipment service shops. The response of the radio public was very positive, especially because the audio amplifiers were fully assembled and immediately operational. Results could be directly obtained so circuit experimentation was not frustrated by the problems of assembling the audio amplifiers.

Chapter 3

FROM INSTRUMENTS TO RADIOS THE PRE-TEN SERIES

MODELS 1 THROUGH 4

In telling of the development of Atwater Kent radio receivers, the author has chosen to use a brief technical review of each set as it appeared on the scene, as a way to give order to the story. Where a major change in the technology of radio design or of manufacturing capability took place, it has been illustrated by describing the changes to the radio sets that were affected, e.g., ganging the tuners. Where a major change in the expectations of the general radio listener or in the content of radio programming came along, it too has been related to the radios current at the time, as, for example, spreading the broadcast stations across a wide spectrum. Also, the effects of styling trends have been described when they became apparent, such as changing from the Open Sets to the simple mahogany boxes. We start with the first set he made, the Model 1.

MODEL 1, No. 3925

One of the results of the acceptance of Atwater Kent instruments by the public was a plethora of requests to the factory for information about connecting them and assembling complete receivers. The Company suggested, at first, that distributors would be the proper agents for local set assembly, using factory instruments, information and boards for mounting the instruments. To this end, different sizes of boards were made available by the factory. But Atwater Kent soon realized that the distributor/assembler answer to the radio public's demands was not adequate. He recognized that there was a large market for assembled sets, and that a proper response to that market would be a very good business, particularly since he had—in place—a distribution and service organization, and an acclaimed national good name.

Recognizing Atwater Kent's continuing awareness of how successfully his products were received in the market place, it is not hard to believe that he initiated production of complete radio receivers as soon as he could get his factory into position. The dates of initial production of the

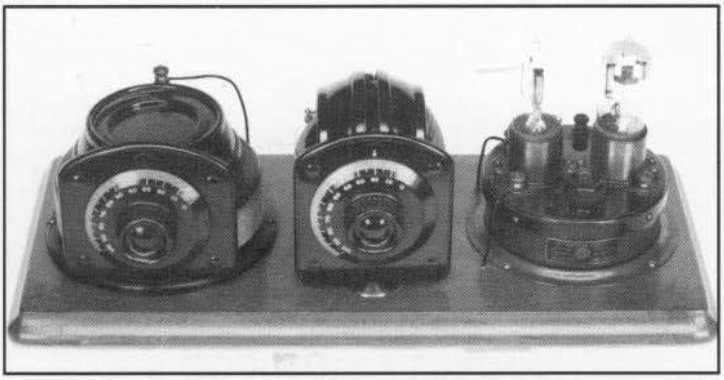


Figure 10. *Model 1 with Variometer. Kent did not use model numbers for the earliest sets. This one was designated No. 3925.*

first factory-built receivers bear this out. Consequently, in November 1922, Kent brought out the first of his factory-assembled sets, Model 1, No. 3925, Figure 10. As sold, the set comprised three major pieces: a Coupled Circuit Tuner, No. 3752; a TA Detector, One Stage Amplifier, No. 3676; and a board, No. 3601 (18½ inches long by 8½ inches wide). An additional instrument could be purchased for use in the set to improve its performance. This was the mounted Variometer, No. 3714, which fitted into the space left between the other two instruments. No instruction for the use or connection of the Variometer was officially made available.

The figure shows one of the two versions of this set, the regenerative model. This configuration was never sold directly by Kent. The production configuration was the same except that the Variometer (the middle instrument) was not included. The reason was that the Variometer made the set a regenerator, and Kent had not licensed that patent from Armstrong. If a customer bought the set from the Atwater Kent organization he got it less the Variometer, but with the space for it left open on the board. He then, or subsequently, could purchase a Variometer, fasten it to the board, wire it to posts on the rear of the tube unit and have the benefits of regeneration.

Many radio collector/historians attribute the idea that Kent did not want to license the Armstrong patents to his independence of attitude. This is then given as the reason for not selling Model 1, No. 3925, and the other members of its family, with the Variometer attached. Such an explanation falls far short of understanding Atwater Kent's perception and acumen. He entered the radio market as a result of having earned a well-deserved reputation as the supplier of electrical systems, not just parts. He had developed and marketed complete ignition systems, including the distributor, high-voltage coil, condenser, wiring and controls. Further, he produced and sold automotive-electrical systems, including the generator,

starter, battery, wiring and controls. He had experienced customer needs and fulfilled them with stable, effective, electrical equipment. His factory had been tooled up to produce outstanding quality instruments, which could not have been done by a fly-by-night outfit. Kent was competitive in the automotive field, hardly a place for blind independence.

Collectors have occasionally suggested that using the blank board was a means of offering the advantages of the regenerator without paying royalties to its inventor—that it may have been Kent's intention to avoid the license. Another explanation that is sometimes offered is that although Atwater Kent might have been responsive to customer demands, Armstrong and Westinghouse limited the number of licenses so that Atwater Kent could not officially sell that circuit.

There are three stronger considerations for Atwater Kent's rejection of regenerative circuits as the mainstay of his product line. First, the circuits involved were not easy to tune. The radio fan or amateur operator had to have a working knowledge of the adjustment procedure, and a lot of patience if he wanted to receive the weak signals for which the regenerator was advantageous, especially if there was a strong signal on a frequency close to the one he wanted. Kent instruments were among the best for this use, but even so, they did not reduce radio listening to the simple art that had to come along.

The second factor, which became a major disadvantage as receivers became popular, was the strong tendency of a regenerative circuit to go into oscillation. (From an over-simplified standpoint, an oscillation was regeneration that had gone too far.) Because a radio listener could not hear the oscillation on his own instrument, the result did not seem bad to him. However, the oscillation created a second transmitted signal, extremely close in frequency to the desired signal, and annoyingly apparent to other listeners in the vicinity of the oscillating receiver.

Third, the regenerator was not effective enough to survive in the family scene. It was not a stable, easy-to-tune radio. It did not have the utilitarian quality necessary for home use. While a patient, persistent radio enthusiast might make the regenerative receiver behave well, it certainly was not what the distaff side of the family later came to consider an important radio friend. Kent realized this during the instrument-only period in the radio business and, consequently, sought other circuits that would do the job he knew had to be done. For these reasons, he had no strong, enduring interest in the regenerator, or in the reflex, and probably did not feel their licenses would be worth the royalties.

Kent did not reject the licensing of patents. In fact, he offered licenses for the use of other patents (ignition) and obtained licenses for other radio patent uses (Hogan for single-shaft tuning and Rice-Kellogg for electro-dynamic loudspeakers). In any case, the regeneration circuit license

is an interesting sidelight of the business side of the development of early radio.

Recognizing a factory-built Model 1, No. 3925, Open Receiving Set today is a difficult job. The craftsmanship which came to mark under board wiring on later models had not developed when that set was manufactured. There appear to be two ways the wires were routed from the Coupled Circuit Tuner to the TA Detector 1 Stage Amplifier. In one, the wires cross and were insulated by spaghetti at the crossing point where they were restrained with a staple. Other staples were used where the wire came through the holes in the board. In the other method, the wires were routed rectangularly, which avoided the crossing, with the wires restrained by staples in the corners of the right angles as well as along their lengths.

Since the factory did not install the Variometers, there was no standard way in which this was done. The simpler connections were made by shaping bus wire to go directly from the binding posts on the Variometer to the TIC binding posts on the TA unit. The dressier way was to bring the wires down from the Variometer, across under the board and parallel to the other wires, and back up in radial lines to the TIC binding posts. The authenticity of a No. 3925 set cannot be validly questioned on the basis of wiring (given that the wiring is of the correct time period.) The sets were offered as wired receivers, or as kits of parts to be assembled and wired by the distributor, or by purchases of individual parts with assembly by the radio fan himself. All these variations must be considered as prime examples of the first Atwater Kent Open Receiving Set.

This point may be emphasized further. Other circuit arrangements were suggested by the factory and provided by distributors. Experimenters tried still other variations. To say that these sets are not authentic, even though they are not the classic Model 1, No. 3925 or another standard set, is to miss a major point in early radio history. Nearly a year of growth and development went by, from the introduction of the first instrument until the factory in Philadelphia started assembling sets. Any set prior to the factory's first production radio, therefore, tells a story about its time, its maker, and the people who used it. Digging out these facets of history adds value beyond its intrinsic worth to such a set, and can sometimes even increase its present-day price above that of the early factory models.

Model 1, No. 3925, used the TA Detector, 1 Stage Amplifier unit for its electronic functions. From the user's standpoint it was very convenient to operate. Listening to a local station of 100-watts output and using a 70-foot antenna, the regenerator version would have produced a loudspeaker output sufficient for a small, quiet room. The simple detector version would have been heard well only with headphones. But because more audio amplification was not easy to connect, Model 1 was limited in customer appeal.

MODEL 2, No. 3945

The next receiver in the line responded to the need for more amplification in a way that was typical of Atwater Kent. From the data listed in one of the very few documents that survived the factory closing, the second radio receiver assembled by the factory was introduced into production one week after No. 3925. It too had a part number, No. 3945, illustrated in Figure 11. This was the second factory-produced Open Receiving Set manufactured by Atwater Kent and is therefore designated as Model 2. In many ways, it is similar to the first set previously described. Stations were selected by the Coupled Circuit Tuner, No. 3752, with detection and signal amplification provided by the TA Detector, Two Stage Amplifier, No. 3812.

The difference between Model 1, No. 3925 and Model 2, No. 3945 was in the audio amplification. Model 2 had two audio amplifiers where Model 1 had only one. In both sets, the audio amplifiers were fully incorporated in the TA units. The amplifier tubes were socketed on the brown Bakelite covers with the transformers buried in a protective tar fill inside the base. Since one amplifier tube and one detector comprised the Model 1 they were arranged along a diameter resulting in a unit five inches in diameter. On the three-tube unit used on the Model 2, the two amplifier tubes were moved forward of the diameter and the detector was placed behind them. The configuration was a nearly equilateral triangle, which required a larger top, almost six inches across.

Again, as with Model 1, No. 3925, this set, Model 2, No. 3945, was sold without the Variometer to avoid infringing the regeneration patent. After purchase the owner could add a Variometer, making the connections between that instrument and the P1 and P2 posts behind the detector tube, as was done on the set illustrated in Figure 13B. When the Variometer was added the selectivity was improved because regeneration raised the grid impedance of the detector and the increased sensitivity permitted the user to reduce the amount of coupling to the antenna. Without the Variometer, Model 2 was capable of only marginal loudspeaker volume on local stations, even when using a long antenna. However, the regenerative version produced enough output on local stations to please the whole family.

Model 2, like Model 1, could have been wired in two styles. The crossed under-board wires were simpler, and this was probably the factory method, especially in the initial assemblies. The Variometer addition (not part of factory assembly) for this style required the direct connection of that instrument to the P1-P2 terminals on the No. 3812 Detector, Two Stage Amplifier. Again, it must be emphasized that the authenticity of

an early Atwater Kent Open Set cannot be questioned on the basis of wiring as many sets were assembled by distributors and by radio fans. These will not conform in all details to the factory-produced sets.

The left-most instrument in line on both sets was the Coupled Circuit Tuner. It provided the means to match the antenna impedance, usually low, to the detector- input impedance, which was high. Matching was crude at best, since the primary coil of the tuner had only three taps. The instrument also provided a small amount of selectivity since the ball and the inner fixed coil of the instrument were self-resonant in the band around 400 meters, where most of the broadcast stations were located.

The instruments were assembled on an 18½ by 8½ inch board, No. 3601, the same one that was used for the Model 1. The larger diameter of the TA Detector Two Stage Amplifier unit occupied more of the board than the two-tube unit on the other set, but Model 2 did not appear crowded until a Variometer, No. 3714, was added in the empty space between the instruments. Then Model 2 was tight compared to Model 1.

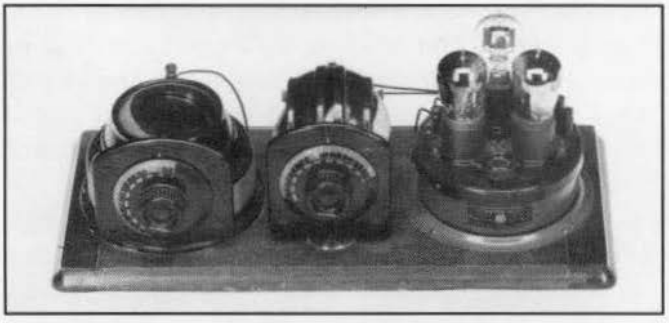


Figure 11. *Model 2 with Variometer. Selling this set, No. 3945, with the plate tuning instrument would have infringed the Armstrong Patent.*

The extra stage in Model 2 was an audio amplifier included between the detector and the output-amplifier stage. Because of the transformer coupling used in all TA Units, it was easy for the designers to add the stage by including another socket on the phenolic top and another audio transformer in the body of the TA Unit and expanding its diameter. The stage was well matched and therefore provided about fifteen times more amplification for Model 2 than the Model 1.

The real meaning of the extra amplification was achieved when Model 2 was modified to include the Variometer in the plate circuit of the detector. Regeneration provided the additional sensitivity to pull in stations from all over the country and the extra audio stage provided volume enough to operate a loudspeaker.

It must be understood that the ionosphere was the reason that distant stations were available to a listener. Even crystal sets could occasionally receive distant stations, but never at loudspeaker level. Whether or not the DX fan could use his loudspeaker when the propagation conditions were right was the contribution of his set's audio amplifiers. Many radio advertisements of the early twenties emphasized the pulling power or distance capability of the advertiser's set, but so little was known of propagation of radio waves along the ionospheric layers that the claims for performance were related directly to the radio set instead of to natural phenomena. But nothing was ever said of the inconsistency of the distant station's reception!

Looking back, one wonders why such claims were tolerated by the public. One explanation is that for the DX fan, repeated reception of a distant station was not an advantage. More than that, it was also an annoyance when a new station, operating on the same frequency but in another direction, was desired for the log. The family radio listener was usually more interested in the reception from a local station whose signal did not depend on multiple reflections from the earth and the ionosphere. Even in 1923 the operators of radio stations realized that their major audiences were local listeners who wanted reliable, static-free reception. They, therefore, increased their radiated power and antenna efficiency to assure strong, stable signals in their primary coverage areas. When Model 2 was released 50-kilowatt stations were still far in the future. WGY, KDKA, and WJZ operated transmitters with 1000-watt outputs. At the same time stations as small as five watts were in operation. By 1925, 2000-watt stations had been put on the air, and by 1928, WGY, the General Electric station in Schenectady, NY, and KDKA, the Westinghouse station in Pittsburgh, PA, had gone to 50 kilowatts.

Atwater Kent did not make claims for the reception of distant stations the backbone of his advertising. Instead, he claimed the quality of his instruments and the quality of their reproduction of music. In the time period when Model 2 was introduced, he had not yet started to advertise the assembled radio. His ads for that time made the public aware of his instruments and their uses. The advertisement for the radio itself appeared later in 1923.

A distinguishing feature of early Atwater Kent instruments was their color. The metal cans of the TA units were painted a distinctive gray-green color. The factory referred to the color as gray, but to the eye of a modern beholder, the color is clearly a green, albeit on the gray and khaki side. Originally, the color must have been made from true green mixed with enough black and white to pull it well toward gray. In addition, a little red must have been added to give a brown cast to the overall hue.

This becomes apparent when the color is matched by using the pure pigments available today.

Kent's workmen must have experienced the difficulty of color-lot matching that was the fate of all others who chose distinctive colors to identify their products. The paint craftsmen at the time of Model 2 could match new paint-colors as closely as desired, but they could not predict the color change that occurred as an inevitable consequence of aging. As a result, authentic Atwater Kent greens can now be found in shades darker and much lighter than the original, and with more red or much more yellow in hue than that which was originally considered standard. Perhaps the best place to look for the original color is on the bottom of a TA can, or, if the collector is lucky, on a new boxed unit that has seldom seen the light of day.

In both of these sets, Model 1 and Model 2, Kent provided an integrated unit, the Detector Amplifier, which contained all the difficult connections. For several years subsequent to the time of these sets, the same or very similar units, using exactly the same construction, were used on all Atwater Kent radios. In retrospective evaluation, it is clear that these integrated units made a significant contribution to radio development, not so much from their electrical performance, which didn't differ electrically from many other embodiments of the same circuitry, but from their mechanical character. Mr. Kent had very perceptively pioneered the use of steel shaping and phenolic casting to build convenient, effective radio instruments. The units were easy to manufacture and easy to use in assembling different radio receiver designs. They also gave the radios a distinctive appearance, which pleased Atwater Kent and provided the basis for eye-catching advertisements of the product line.

MODEL 3, No. 3955

The radio market in 1922, although well established and growing explosively, differed greatly from radio as we know it today. The reasons are numerous and interesting to radio historians. They are also important in understanding some of the actions taken by Atwater Kent in making receiving sets for that market. A quick review provides a background for understanding Model 3. Broadcast stations had been on the air for two years, but they did not generally broadcast commercial messages for agencies other than their owners. Rental service, where the transmission facilities were made available so that users other than the owner could announce their goods and services, was initiated by AT&T, using their NY-city station, WEAF. For owners of radio stations in late 1922, their use was akin to present-day institutional advertising. Stations owned by

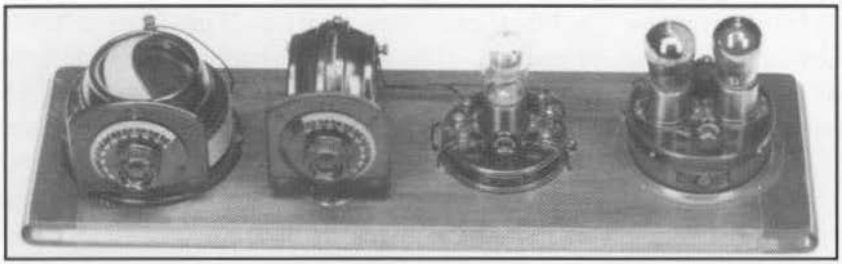
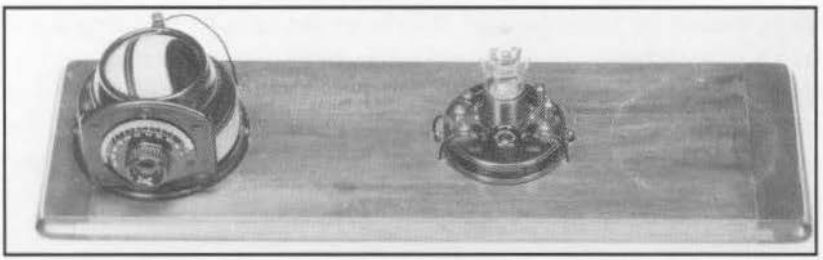


Figure 12A (above). *Model 3, complete. All the components have been shown on this set. See Figure 12B for the bare set.*
Figure 12B (below). *Model 3, without additions. The Variometer and the 2 Stage amplifier would be purchased to upgrade the one-tube detector to a radio equivalent to Model 2.*



department stores were used for commercial messages concerning the store, but stations owned by groups like churches or individuals tended toward cultural or informational subjects. Program content was strongly musical, with lectures, sports events, and readings interspersed.

In the home, the radio was a special object, listened to more intently than today when it provides background as much as it does direct information or entertainment. Radio in 1922 filled the needs of people that are met today by television. In those times, a complete radio set was expensive for the average wage earner, both in dollars and in hours of labor. Atwater Kent's first family of radios ranged from $25 to $49 for the set itself, with a further expenditure of $40 for accessories such as tubes and batteries. In addition, a sound reproducer was needed. Prices ranged from $3 for headphones to $35 for a loudspeaker. The complete set, ready to play, could cost $125. This corresponded to about 200 hours of work for the average wage earner.

A concept, which is so familiar to the radio and television audience of today as to go unnoticed, was born in the time period of Model 3. It was the transmission of a program from a location separate from the station. Initiation of the program could be in a studio at another stations or, more commonly, at a location separate from all of the stations, such

as a sports arena or a political executive's office. The concept has come to be called remote operation. The first experiment with this concept was performed by AT&T in the fall of 1922, when a football game, played and described in Chicago, was broadcast in New York by station WEAF.

In January, 1923, WNAC in Boston and WEAF made the first simultaneous broadcast of a program. It was originated in the studios in New York and aired in both cities, sponsored by the Shepherd Stores who owned WNAC. This was indeed an exciting time in the development of radio and was the result of expanding the idea of the remote to include transmission from several stations simultaneously. This was called network operation.
The listener's part of radio was also experiencing the expansion from the effect of sharing the world in the home as never before possible with printed matter or records, and also from the idea of building a receiver to tune in this newly available world. Experimenters made up a large proportion of the radio market in 1922 as compared with the number of purchasers of factory-made radios. The word "experimenter", as used here, identifies radio fans of all kinds who built receivers using parts and circuits available at radio, hardware and variety stores.

Set manufacturers were not yet able to forecast what radios should look like or how they should be operated. Some customers readily accepted complex panels with difficult tuning adjustments; other customers were interested in building simple receiving sets to try them out. Still others wanted to assemble kits of the radio circuitry and incorporate the finished product into furniture of their own construction or modification. A radio manufacturer of the time had to respond to this broad range of interests if he wanted to maximize his penetration of the market. The Radio Corporation of America, which of course meant General Electric, offered a complete line of parts and a growing line of complete radios. (RCA was incorporated in late 1919 as a subsidiary of GE to convert Marconi interests to American ownership.) Cross-licensing agreements were reached with AT&T, and later with Westinghouse, in which RCA became the commercial receiving-set outlet for all three companies. RCA at the time had no manufacturing operation. Federal, DeForest, Grebe and many others also provided parts and sets for this emerging market. Since Atwater Kent had entered the radio business with the intent of expanding his production, he covered all areas: individual instruments and assemblies, such as the TA amplifiers, that could be made into receiving sets; fully assembled sets; and different models to satisfy a broader range of customers.

Earlier in this series, the first two factory sets, Model 1, No. 3925 and Model 2, No. 3945, were reviewed. These were complete receivers

needing only a sound reproducer, tubes and batteries to operate. No provision was made in them for buildup from a simpler set to the final version. Atwater Kent then entered another part of the market, the upgrade of simpler sets with a modified version of his second offering that offered the build-up concept.

A third form of the TA unit, the two-stage audio amplifier, was the key instrument of the next receiver in the 3900. This set was Model 3, Part No. 3955, Figure 12A, introduced only one week after Model 2. The figure also shows the Variometer that could be added after purchase. The full configuration of Model 3, No. 3955, was, from left to right, Coupled Circuit Tuner, Variometer, Single Tube Detector, and Two Stage TA Audio Amplifier. A companion set, No. 3960, Figure 12B, came out at almost the same time (two days later.) No. 3960 was of the same basic form of the No. 3955, but was sold with only the Coupled Circuit Tuner and the Single Tube Detector mounted on the board.

Apparently not all the customers that Atwater Kent sought to reach were interested in obtaining a complete radio in a single purchase. With the line of easy-to-add instruments that he had available, Kent could offer a one-tube, simple detector radio such as No. 3960, which the customer could upgrade in two steps, each representing another sale for the dealer. First, perhaps, the customer bought the Variometer and had the benefit of a one-tube regenerator. When he was ready the customer could have returned and bought the two-tube amplifier to complete Model 3, No. 3955. He would then have enjoyed a radio equivalent to the regenerative detector, two-stage audio amplifier sets generally available from many contemporary manufacturers.

When the Model 3, No. 3955 was current, upgrading was easy. Kent dealers and other outlets still carried the full line of radio instruments made by the factory, so that the customers could easily alter their receivers to the latest configuration their pocketbooks supported. Examination of contemporary radio sets built at home by radio fans using these instruments reveals as many circuits and layouts as could be conceived, some of them of doubtful capability. It appears that the radio fan was encouraged by the Kent organization to build experimental radio sets as well as to purchase factory-built receivers.

MODEL 4, No. 3975

In the 3900 series of receivers, Atwater Kent manufactured one more set, No. 3975. The difference in the full configurations of No. 3975 and No. 3955 was in the tuning instrument. This Open Set, because of its close relation to the earlier members of the 3900 family, is designated as Model 4. It was produced in the factory and used a similar Detector,

No. 3902 with the TA Two Stage Amplifier, No. 3634. Model 4, No. 3975 was released on December 23, 1922.

The major difference between Model 4, No. 3975 and the earlier sets was the use of the Variocoupler No. 3731 as the station selector instead of the Coupled Circuit Tuner, No. 3752. Used in the earlier sets, this instrument was designed to resonate the user's antenna and thereby transfer a maximum amount of signal from the aerial to the receiver. The capacitive reactance of the aerial was nullified or canceled by using the inductive reactance of the tapped coil placed in series with the aerial and ground. The Variocoupler was made of a tapped-stator inductance, inside of which was a rotor similar to those on the Variometer and the Coupled-Circuit Tuner.

Together these inductors and the aerial capacitance formed a tappable, tunable circuit resonant in the broadcast band, which at that time meant from a little less than 200 meters to a little more than 500 meters. By resonating the aerial the current in the primary was maximized and the voltage induced in the secondary (rotating coil) was maximized. In the Model 4, No. 3975 set, the rotating coil was connected so as to act as a variable-ratio auto-transformer.

By using these taps and rotating the inner coil, the operator changed the effective turns-ratio between the antenna circuit and the grid circuit of the detector. This enabled him to maximize the transfer of antenna energy to the detector (impedance matching). When this more-efficient matcher was used with the regeneration available by means of an owner-installed Variometer, the set was the most effective member of the No. 3900 series for receiving weak stations. On stations strong enough to push the regenerative detector to maximum output, no advantage was gained from the matcher, although the volume could be controlled by mis-matching.

The remainder of the Model 4, No. 3975 Open Set was identical to Model 3, No. 3955. The board, the Detector and the TA Two Stage Audio Amplifier were the same and were assembled identically in the two sets. Also identical was the option of connecting a Variometer in the plate circuit of the detector for regeneration. The performance of Model 4, No. 3975 Open Set was, by today's standards, marginal at best. Station selection was very limited since the set was dependent on the characteristic of the aerial. The amount of inductance change that could be achieved by rotating the secondary coil was small. Consequently, the results were affected more by factors such as aerial placement and length than by the controls on the set itself. Selectivity may have been good with short aerials but the incoming signal would have been weaker than that obtained with a longer aerial. Conversely, however, the selectivity with a long aerial would have been poor.

For listeners near a city where all stations were on one wavelength and shared time, the selectivity limitation would have meant little. In trying the sets from this first family, Model 4, No. 3975 did not perform as well as Model 2, No. 3945 on a 200-foot aerial. The limitation was selectivity. Model 2 No. 3945 could better sort the stations because the taps on its primary coil permitted tuning the aerial while the other two coils permitted tuning the grid circuit.

A different connection for the Variocoupler that remedied the limited tuning-range problem was to parallel a variable condenser across the rotating coil. The combination was left unconnected from the primary, and instead connected to the detector amplifier. Early Atwater Kent literature gives a circuit using the Variocoupler in this manner for use as the input to a radio-frequency amplifier. The date on the paper is March, 1923.

Very few Model 4, No. 3975 radios have come into collectors' hands. Was that because they were made toward the end of their cycle? Was it limited performance, or less-than-desired performance per investment dollar? One wonders how many No. 3975 Open Sets Atwater Kent produced. The next family of sets doesn't tell how many but it does review what Kent did about regenerators.

MODEL 6, No. 4052

The radio market for receiving sets was well along in its phenomenal growth by the beginning of 1923. Although little more than two years had elapsed since the beginning of entertainment radio, as many as one and one-half million radios had been sold by manufacturers or built by radio listeners. In February, 1922, there were about 35,000 receiving sets in the New York City area that the planned AT&T station, WBAY, expected to cover. By the end of 1923, that same market had grown to half a million sets, and WBAY had become WEAF. Until mid-1923, the main transmitting wavelength for all major stations was 360 meters, with a second wavelength at 400 meters for use in big cities. Assignment of a spectrum of wavelengths had not yet been made. Broadcasters shared time on the single wavelength.

It was a time of burgeoning interest and excitement both for listeners and for entrepreneurs. New radios were being introduced rapidly to meet the demands of this new market. The last few months of 1922 and the first part of 1923 must have been busy times at the Atwater Kent Manufacturing Co. They were still producing electrical system parts for automobiles and had initiated their successful line of radio instruments. The engineering staff worked on both the 3900 series that were being introduced and new radio designs at the same time. The production department not only

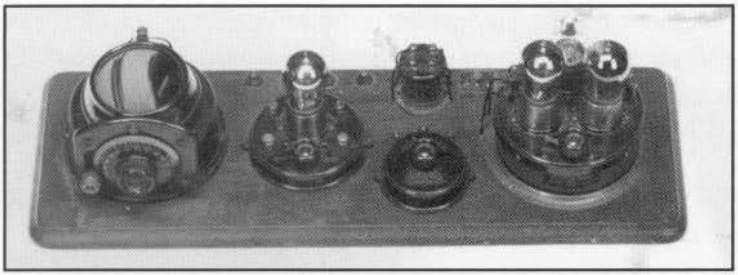


Figure 13. *Model 6. This radio used one fixed-tune RF transformer. The set's selectivity was very poor.*

carried along radio-instrument manufacturing but also had to set up what was entirely new for the factory, receiver assembly lines. With the response from the dealers and distributors in handling the instrument line, the sales force probably made life hectic on Stenton Avenue, the plant location in Philadelphia.

Doubtless, in this beehive of activity, Mr. Kent made his presence felt. From what is known of him through former employees and his son, Atwater Kent, Jr., he took an active part in every phase of the business. He participated in designing, particularly in the mechanical details of how the instruments appeared and how they were finished. He either closely monitored the layout of the assembly areas or supervised that job himself. Kent's insistence on quality was not relaxed, since the instruments clearly show that appearance, function, fit and finish were maintained while new devices were brought on line.

The end of 1922 had seen production begin on five receivers in the 3900 series, but by January, 1923, a new line of radio sets was needed. Since the very effective TA Detector, Two-Stage Amplifier had established a good reputation for Atwater Kent instruments, the basic requirement was to supplement it with a new circuit (not the questionable regenerator.) Amplification of the signal before it reached the detector was required.

With all the important broadcasting stations clustered near 360 meters and sharing time on the air, selectivity was not as important as sensitivity. The signal amplitude at the detector for good detection had to be between 100 and 500 millivolts. Since transmitters had not yet reached even the five-kilowatt level, this was much more than could be delivered by moderately-long home antennas. Signal amplification was needed. Radio-frequency amplifiers had been developed and radio engineers were familiar with their applications. Early versions had been used in the intermediate-frequency stages of Armstrong's and Houck's superheterodyne circuits. They were similar to audio-frequency amplifiers that used transformer-interstage coupling, but operated at frequencies substantially higher,

e.g., 50 KHz. The transformers were still iron-cored, with windings carefully designed to be resonant at that frequency. Extending the operating frequency to 800 KHz was possible, so several radio companies chose this means of coupling RF-amplifier stages and offered radios based on this design. Atwater Kent was one of these. Others, but by no means all, were General Electric (RCA), Erla, Federal, De-Forest and Acme.

An RF-amplifier stage was added to the circuit for the Open Receiving Set No. 3945 to make a new receiver, Model 6, No. 4052, released on January 14, 1923, shown in Figure 13. The new receiver was a four-tube set incorporating the Detector, Two Stage Audio Amplifier, No. 3812, that had been used on No. 3945. The RF amplifier was coupled to the detector by means of an iron-cored transformer shown to the immediate left of the three-tube unit. Early sets did not include a switch for turning off the A battery supply to the filaments. Later sets added this feature.

The interstage radio-frequency transformer made possible a simple radio amplifier that was very similar to the standard audio amplifier used in nearly all radios of the time. Because of the hundred-fold increase in frequency, however, the unit was self-resonant in the broadcast band. The transformer used in Model 6, No. 4052 was marked "2" on its nameplate. It was part No. 3972. Another similar transformer, No. 3802, marked "1", had been offered earlier as part of the original line of instruments. Apparently Kent and his engineers felt that the No. "1" transformer resonated too far below the narrow band of frequencies used by broadcasters in 1922, so the second one was designed to push its self-resonance to about 800 kHz.

In examining the transformer, several details of interest come to light. First is the top deck and its arrangement of binding posts. The similarity to the tops of the TA units and the type-L Audio Transformer is very apparent. The style of the can and its nameplate continue the similarity, clearly marking the transformer as a part of the Atwater Kent product line. Like the type-L audio transformer, it show a family resemblance to some of Kent's ignition coils. Inside the can and enclosed in tar was a cylindrical, grooved dowel about one inch in diameter. Inserted into the axis of the wooden cylinder was a core made of fine iron wires. The primary and secondary windings were jumble-wound in the grooves around the core. The primary used resistance wire and the secondary used copper wire; both were cotton-covered for insulation. The highest expected non-regenerative amplification for the RF stage, using the No. 3972 Transformer and a type-201A tube, would have been about 13 times at 760 KHz. With the type-201 tube, the amplification would have been slightly less.

Antenna tuning, which was the means of station selection within the pass-band of the fixed-tuned transformer, was accomplished using a Type-11 Tuner,

No. 4051. It was similar to the Coupled Circuit Tuner in its mechanical construction, but differed by not having the tapped antenna coil around the outside of the base. With short antennas (which are like condensers in electrical behavior) the inductance of the Type-11 Tuner coils increased the impedance of the input circuit by resonating the antenna's capacity, and thereby increasing the signal voltage at the amplifier grid. It was used by connecting the antenna to the top binding post.

The similarity in part numbers of the Type-11 Tuner, No. 4051, and the first radio it was used in, No. 4052, is very revealing of Atwater Kent factory practices. When the set was conceived and planned, the question of antenna tuning and the use of the Coupled Circuit Tuner was considered. It may well have been put: Can we hold down the cost of this set by using an antenna-tuning instrument simpler than the Coupled Circuit Tuner or the Variocoupler? That answer, based on the 360-meter assignment of station wavelength and the general use of antennas less than 200 feet long, would have come out indicating that the Variometer would work well.

The next question would then have been: Would it be better to use the Variometer or modify the Coupled Circuit Tuner? The answer was to modify the Coupled Circuit Tuner. This conclusion is based on three factors typical of Kent's attitude; appearance of the instrument on the board, customer familiarity with the Coupled Circuit Tuner, and the association of the Variometer as a supplementary instrument in the 3900 series of receivers. The result was the addition of an instrument to the product line, and its immediate incorporation into the new family of receivers. The number assigned was the next in the book. Then the set itself got a number, which was, by coincidence, the one immediately following.

Also added to the new set was another new instrument, the potentiometer, Part No. 3978, connected across the filament circuit. The grid of the RF amplifier was returned to the arm of the potentiometer through the Type-11 Tuner. The purpose of the potentiometer was to change the bias (grid voltage with respect to the filament) and thereby change the amplification of the RF stage. The idea of controlling amplification seems straightforward to a modern radio listener; we are all familiar with volume controls. But in this radio and many others of its time, the function was neither as simple nor as direct as it became later.

In Model 6, No. 4052, the RF-amplifier stage had a strong tendency to regenerate by feeding energy from the plate circuit of the amplifier back to the grid circuit through the plate-to-grid capacity of the tube. Because the plate circuit was broadly tuned and heavily damped, the phase relation between plate and grid did not make oscillation a high risk, although with a tube that had a very active filament and a high B+ supply oscillation was probable.

The potentiometer enabled the set owner to vary the stage gain by biasing the tube negatively (toward the minus side of the filament supply.) Volume control using the potentiometer might better have been described as a sensitivity adjustment. The inherent possibility of regeneration made for potential stage-gain above the nominal value of the tube and transformer. Using the control carefully, the owner could increase sensitivity to the point where the set was as effective as a good regenerative detector with only a moderate risk of oscillation. It was then capable of receiving stations with signal strengths of one millivolt per meter at the receiving antenna.

However, the potentiometer did not provide a sufficient means of reducing the RF amplification on strong signals. Instead, the filament control built into the No. 4024 tube socket was used. The amount of amplification in a radio tube such as the type-201 depended strongly on the filament emission, and consequently on the temperature of the filament in the range of current from about 0.6 to 0.8 amperes. Below 0.6A there was little or no emission, and above 0.8A, the emission reached a saturation value. Within these limits, the tube operation would vary from no amplification to its designed value.

Since the signal level at the RF amplifier was a very small voltage, the limited emission amplifier did not introduce large distortions even though the tube characteristics were greatly changed by the volume-control function. The filament control, in combination with the bias potentiometer, provided a satisfactory, although complicated, way of controlling the output volume of the set from very soft to loud.

With the Model 6, No. 4052, the under-board wiring technique, familiar to collectors of later breadboards, reached its mature form. Spaghetti insulation was used on wires going through the board and on wires carrying RF currents or running close enough to touch if disturbed. Staples were used to secure the wires, being placed at corners, at intervals along straight runs, and wherever a joint was required. Joints were made by soldering about 3/8 inch of touching parallel wires. These were secured by a staple and then soldered, using a heat shield between the wires and the board.

Another Open Set was produced shortly after No. 4052 to appeal to customers who did not want to spend the money for a three-tube unit and a speaker. It was based on No. 4052, used a fixed-tune radio amplifier, and was assembled on the same board. The set was identified as No. 4120, with a No. 3902 single-tube detector instead of the three-tube unit. It was, therefore, a two-tube set that would have been attractive to someone who already owned a two-tube amplifier. No. 4120 and its completely built-up version, Model 6, No. 4052, were not high performance

receivers. With only the single fixed-tuned RF amplifier, their selectivity and overall sensitivity were less than a well-tuned three-tube regenerator.

MODEL 7, No 4066

By 1923 radio engineers had found that the grid-leak detector followed by two transformer-coupled stages of audio amplification produced good output volume when the detector was operating with signals in its effective detecting range, a value of about 200 millivolts. This was the basis of the Atwater Kent three-tube unit and of the detector-two-stage amplifier circuits offered by many other manufacturers, such as the RORK from Grebe and the 525 from Kennedy. But more audio stages didn't solve the problem of insufficient signal from the antenna at the detector. RF amplifiers (and regeneration) were deemed effective and were investigated.

Experience soon showed that one non-regenerative radio-amplifier stage was not enough, even with a long antenna. Adding another stage was practical, although a little more expensive. That was the basis of No. 4066, the five-tube receiver shown in Figure 14. Designing the Atwater Kent open sets was not a difficult task. It consisted largely in putting together an attractive (to Mr. Kent) sample, making drawings of the new instruments and its assembly for the factory. The similarity of No. 4066 to its immediate predecessor makes this apparent. With the Model 7, No. 4066, Atwater Kent passed another major milestone in his development of vacuum-tube radio receivers. It was the first five-tube set produced by the factory.

No. 4066 was closely related to No. 4052. The difference was only the extra RF amplifying stage (and the board) but the result was a set capable of converting the signals from local 100-watt stations to loudspeaker

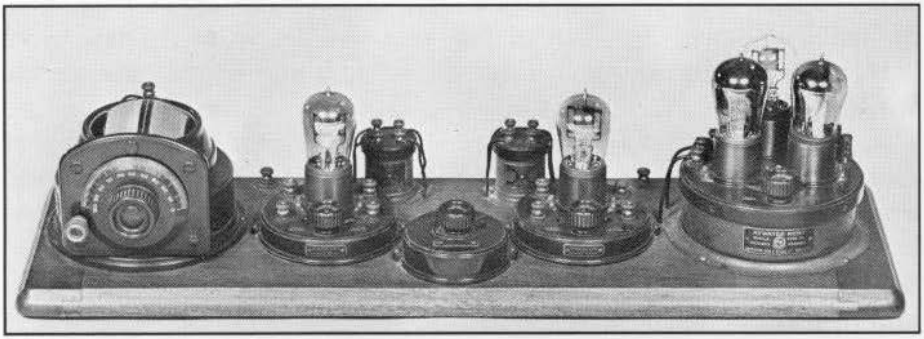


Figure 14. Model 7. *Two RF transformers were used here but the selectivity was still very poor.* *Photo: Alan Douglas*

volume for family listening. Model 7, No. 4066 also could achieve fair reception from stations up to 100 miles away. In early 1923, radio stations had reached the 1000-watt power level but they tended toward horizontal radiating aerials. The era of the quarter-wave vertical monopole with its extensive radial system had not yet dawned. Therefore, the coverage of the kilowatt station was poorer than is expected today, although the difference in the favorable direction was small. A kilowatt station might have been expected to produce a signal strength of 10 microvolts per meter at a distance of one hundred miles. A radio listener with a 100-foot aerial might then have been able to deliver to his radio set a voltage of 300 microvolts from the 10 microvolt-per-meter signal. This example assumed that the aerial was carefully placed and that it was properly matched to the set. Model 7 would have delivered a low-volume loudspeaker output.

The radio fan in the early twenties expected to install a long aerial. He would have been limited by his property and structures, but could have easily arranged his directions to be effective in picking up the transmitter wave. With two RF amplifiers and the TA unit, the overall amplification of the No. 4066 set was as high as 50,000. A 50-microvolt signal would have been boosted to 7 volts in the speaker line, a value sufficient to operate the speaker reasonably well. The radio listener might have reduced the amplification of his set on such a signal by using the potentiometer to save battery energy.

The primary function of the Type-11 Tuner was to provide the means to match the aerial to the grid of the first RF amplifier. The coil inductance resonated the aerial capacity, acting to transfer the antenna energy to the grid without appreciable loss. At the same time as the desired signal was being efficiently transferred, however, unwanted signals were being rejected but not strongly. Station selection in a Model 7, No. 4066 was also accomplished by another means—the characteristics of the RF transformers. As was detailed for the No. 4052 receiver, the radio-frequency transformers did not respond equally over the total band reserved for broadcasting. They were too broad in the middle of the band. With the second RF transformer, the unwanted signal rejection of the No. 4066 was improved a little over the No. 4052 and the earlier sets. While stations were all operated in the 400-meter wave band, the fixed-tuned stages provided only amplification (not selection), since they were responsive to wavelengths in the range from 400 meters to 360 meters. The set was not selective enough for use when the broadcast band was assigned.

Model 7, No. 4066's electrical design was a little more challenging than just laying out a new board, since using two of the radio transformers from the earlier set, No. 4052, would have resulted in oscillation of the

two radio stages, even with the gain reduced by the potentiometer. The coupling in the tubes and between the transformers was too high for stable operation. The solution was to use the slightly different fixed-tuned RF transformer, No. 3972, the early one that Kent had sold as a separate part, and marked "1". In No. 4066, it made the first stage of RF amplification self-resonant at a lower frequency. Moderately stable operation was obtained using "1" in the output of the first stage, with "2" in the output of the second stage.

When Model 7, No. 4066 was released on January 24, 1923, it was novel in more ways than just being the first Atwater Kent receiver with five tubes. It also was the first set to be offered for sale contained in a cabinet. The cabinet, which appears to have been a desk model, was made independently of the receiver by an outside supplier. (Kent had not yet ventured into the furniture business.) The radio apparatus, assembled on a board, was fitted into a compartment in the main body of the cabinet. That radio was assigned Part No. 4220 and carried a release date of May 8, 1923. At the present time, no still-existing examples of the cabinet set have turned up.

If the No. 4066 was adapted from the open-set style to the cabinet style in a manner similar to that used on later sets, such as Model 10, the main difference between the two styles would have only been the board. Cabinet sets used a board that was cut with straight sides instead of the ogee curve used on the open sets. The board sizes would have been very close for both styles. The Model 7 Open Set used a No. 4056 mahogany board, 8½ inches by 26½ inches. The cabinet board would probably have been about 3/4 inches smaller in both dimensions and made of a less costly wood such as bass, finely finished on the top surface only.

Model 7, No. 4066, was produced with minor variations from one pre-production run to another. Some sets came without the on-off switch. Others used a square-dress panel on the switch, similar to the one shown on No. 4052. Still others used the round Bakelite switch that was incorporated in subsequent receiving sets. Other variations found in No. 4066 were in the wiring under the board. The exact layout of the wires, the length of the spaghetti insulating the wires, and the use of eyelets for the wires coming from the top side were not identical in all sets. The concept of uniform factory practice in details such as wiring had not yet displaced the craftsman concept in Atwater Kent's factory. The production rate would have to rise much higher before the need for selective assembly would displace complete-set assembly.

THORIATED FILAMENT TUBES

At about the same time that No. 4066 was put on the market, type-200A and type-201A tubes became available. They were intended as

replacements for the types 200 and 201, the five-volt filament detector and amplifier tubes that had been used since the beginning of the radio-entertainment industry in 1920. The advantage of the "A" tubes was their thoriated filaments and the consequent reduction of required filament current from one ampere to one-quarter ampere (at five volts.)

Atwater Kent brought out another version of No. 4066, adapted to use the new tubes. This set was assigned part No. 4205 and was released on April 30, 1923. One difference between the two sets was the replacement of the TA Detector, Two Stage Amplifier, No. 3812, used in all earlier sets having this instrument with Part No. 4135. These instruments were functionally similar and were the same gray (green) color. The filament rheostat in the latter unit was increased to six ohms to adequately control the "A" tubes. The other difference in the sets was the replacement of the No. 4024 tube units with the quarter-ampere versions, No. 4175.

While the technology of vacuum tubes is not directly a part of the Atwater Kent story, the improvement in filament characteristics of the type 201A over the type 201 had a favorable impact on the marketability and design of the sets. The difference in filament current meant a four-to-one increase in the time between recharges of the filament storage battery, or a four-to-one reduction in the cost of heating the filaments. Storage batteries used with sets like No. 4066 had capacities of about 50 or 60 ampere-hours at 6 volts. Such a battery would provide four amperes of filament current for about two weeks if a listener used his set an hour a day. An average price for getting the battery charged was 50 cents, so the cost to light the filaments of the No. 4066 with one-ampere tubes was as much as five cents a day. Changing to the "A" tubes in a set like No. 4066 translated into a saving of more than 25 cents a week for that listener.

While the saving was significant, the larger cost of operating the set was plate power. The B batteries were expensive. A listener who kept his filaments as low as he could drew less than 20 milliamperes from his B batteries, and at that rate, they lasted for up to 75 hours. But, since a pair cost about $7, the cost per hour for B batteries was 10 cents, somewhat more than the A power, especially after the new tubes were introduced.

The other main impact that advances in tube manufacturing had on radio-set design was the trade-off between circuit complexity and amplification. When tubes cost six to eight dollars each, it was cost effective to make circuits complex by using inductive instruments and regeneration. As tube production increased and prices dropped, more tubes could be used without raising the selling price. Tube amplification replaced circuit tricks. The No. 4066 reflected this change in approach through the use

of the two amplifier tubes and simple (and inefficient) radio-frequency transformers.

The added sensitivity that was obtained with Model 7, No. 4066 was not of great benefit. While this resulted in more even amplification of the two mainly used wavelengths, the radio was very broad in its response band because of the stagger-tuning of the amplifiers. This was a severe limitation when, in late 1923, the Radio Commission reassigned station frequencies across the entire broadcast band. The very limited selectivity of the Type-11 Tuner meant that stations across the band came in almost equally well and the listener could do almost nothing about the interference, except to install some kind of a wave trap. Unfortunately for Atwater Kent's recovery of investment, the lack of frequency discrimination in No. 4066 resulted in almost instant obsolescence; fixed-tuned radio amplifiers were a dead end, except for use in superheterodynes. But in late 1923 superheterodynes were not a viable product line for Atwater Kent even if a license were obtainable. His capability was confined to multi-stage tuned-radio-frequency-amplifier sets.

No. 4066 also had a companion set in the same way that No. 4052 had its companion, No. 4120. It was No. 4275 released on June 5, 1923. As with No. 4052, the difference was the substitution of a No. 3902 detector for the TA Detector, Two Stage Amplifier. Atwater Kent had carried the concept of progressive set build-up from Model 3, No. 3960 into these two sets, but his business had changed from supplying parts to full-set manufacturing and therefore no longer benefited by the concept of progressive build-up. No. 4275 was the last set produced by Atwater Kent using the single-stage detector unit, and the last partially-complete model he offered to the radio market.

MODEL 5 and MODEL 8

Atwater Kent designed two other sets in the 4000 group. They were based on Model 7, No. 4066, but they looked so different that a detailed analysis was required to establish the similarities. One was Model 5, No. 4333, Figure 15, the first of the open sets to be alternately identified in the sales literature by a Model number. It was widely advertised as Model 5. The top view illustrates the radio but it does not make clear, except for the knob and tube count, why this was a variant of No. 4066. Electrically, Model 5, No. 4333 was identical to Model 7, No. 4066, with one exception; the radio-frequency amplifiers on Model 5 shared a common filament rheostat. Both sets used Type-11 tuners in the antenna circuit, and included two RF amplifiers with their iron-cored interstage

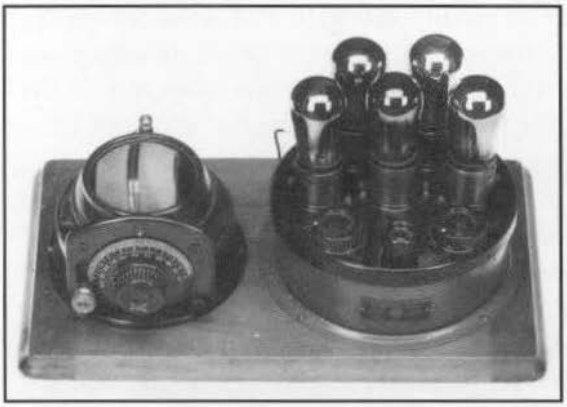


Figure 15. *Model 5. Inside the 5-tube can are all the parts from Model 7 except the Tuner. It had good amplification but poor selectivity.*

transformers. Model 5 was introduced on September 7, 1923. The figure shows the two instruments which made up Model 5—the Type-11 Tuner, Part No. 4051, and the Five Tube Amplifier Unit, Part No. 4330.

The Five Tube Amplifier, Part No. 4330, was a table-mounted metal can, similar in appearance to, but larger than the three-tube TA Detector, 2 Stage instrument. It carried five tubes: two RF amplifiers, the detector, and two AF amplifiers. The photo shows the tube arrangement. To the left were the RF amplifiers, the first being furthest toward the rear. To the right were the AF amplifiers, the output stage being rearward. The tube in the middle of the instrument was the detector.

Transformers were used to couple all the stages. When this instrument was designed other means of coupling were known but were not in common use. Since tubes were still expensive, Kent's engineers wanted to minimize their number (i.e., maximize the stage gain.) For the audio, the interstage transformer was almost like another tube as far as overall signal amplification was concerned. Moreover, the high cost of using B batteries, because of the voltage drop and the energy loss in the plate-load resistor of a resistance-coupled inter stage led to more expensive operation than with transformer coupling.

While the positive feature of resistance coupling was reduced distortion and wider frequency response than for transformer coupling, this was only a limited advantage in 1923 since loudspeakers, especially horns, were not generally capable of reproducing the bass tones. The larger needle-cone magnetic speakers could show the difference between resistance and transformer coupling for poor transformers, but for good transformers the difference was still indiscernible.

As an example, the first loudspeaker in the Atwater Kent line was the Type-M, a diaphragm-driven horn. It did well compared to others in

its class, being carefully made of quality materials to a good design for the diaphragm and magnetic structure. Like other horns, however, its lowest useful frequency was related to the maximum diameter of the bell. The lowest frequency for fully effective transfer of sound from horn to free air was that whose half wavelength was the maximum bell diameter. For the Type-M the diameter was 15 inches. The lowest primary frequency was, therefore, about 400 Hz. The octave below this frequency was reproduced partially, but the efficiency dropped sharply with decreasing frequency. Intelligibility for voice recognition or for instrument identification requires a band from about 300 Hz upward, so the speaker was satisfactory for radio in 1923. But for such a reproducer, resistance coupling was not the kind of choice Atwater Kent would make.

RF amplification was also accomplished using transformers as the inter stage couplers in the Model 5. They were mounted directly under the RF tube sockets, being suspended by the bus wire used to electrically connect them into their circuits. The transformers were similar to those used on No. 4066. Both RF transformers used iron wires for their core material. The secondaries were wound with fine copper wire in the groove closest to the Bakelite tube deck. The primaries were wound with resistance wire in the other groove. The spacing, diameters, number of turns, and core material were adjusted to make the transformers work very well in the range from about 700 KHz to 1 MHz.

Frequency assignments for broadcasting were expanded in the middle of 1923. This meant that sets using only a single tuning instrument were no longer satisfactory to the radio market because of their poor selectivity. Potential buyers demanded the capability to hear only the station of interest, regardless of the presence of other stations on wavelengths nearby. Almost before its introduction, the Model 5 was doomed. Yet it was introduced. Why?

One explanation is that the radio was already in production and plans could not be changed. While plausible, that explanation misses on two counts. First, it doesn't account for the Model 10 which was also introduced on the same day. Model 10 was provided with selectivity enough for both 1923 and today. Clearly, selectivity had been addressed by Atwater Kent before Model 5 was introduced. Second, it doesn't explain the Model 8 (see below), which also addressed the selectivity problem. That set added instruments to enhance selectivity.

The best explanation for introducing the Model 5 is the Five Tube Amplifier containing the active circuitry. This is another evidence of the Atwater Kent's interest in reducing manufacturing costs. It was

one of his efforts to reduce the size and complexity of radio sets. Five tubes had been found to be the best compromise for tuned-radio-frequency receivers. Atwater Kent had achieved extensive acceptance of the three-tube TA Detector Two-Stage instrument. What was more natural, considering the capability for metal working and molding, than to combine these into a complete radio? Introduction of such a set would sample the market for what history was shown was needed—a small self-contained, fully-enclosed table set. Atwater Kent was on the right track. The problem of selectivity drove him off, but as later sets show, only temporarily. He came back again with the Model 20, and with the Model 40 series.

The big difference between Model 5, No. 4333 and its predecessor, Model 7, No. 4066, was the use of a single drawn-steel container to house all the parts that had been separately packaged in the earlier set (including the parts that were located in its TA Detector, Two Stage Amplifier.) The construction of Model 5 represented the greatest degree of integration and size reduction achieved by Atwater Kent. It shows how much he was influenced by the potential use of shaped steel to provide an exoskeleton that was attractive to the eye, easy to manufacture, and reasonable in cost. Other manufacturers such as Westinghouse and General Electric used shaped steel to enclose the catacomb that was the main part of the early RCA superheterodynes, but the result had the look of utility, not esthetic beauty. The point of beauty can be argued, but the acceptance of the open sets in their own times, and the enthusiasm of collectors in our time, testify to the visual effectiveness of Kent's taste.

The late introduction of Model 5 suggests that more engineering work than simple adaptation was required to complete its design. Working with the set, and particularly checking the electrical performance, suggests that substantial modification was needed to make the set stable. The closeness of the radio tubes and their transformers must have caused an increased tendency to oscillate. Surviving Model 5 receivers have enough unwanted feedback to make them oscillate when especially effective type-201A tubes are used in the RF stages and the plate voltage is higher than about 45 volts. The author tried to measure the amplifier performance of his Model 5 (the one pictured.) The results were disappointing, particularly when compared to the expected performance based on measurements of the transformers alone. The set had a strong response at 500 KHz, and a moderate response at the expected 800 KHz. The 500 KHz response seems to indicate positive feedback near that frequency. Had the set not been obsoleted by the need for selectivity, it might well have turned into a bad sales problem. This resulted from the reassignment of frequencies by the Radio Commission at almost the same time as the Model 5 became available.

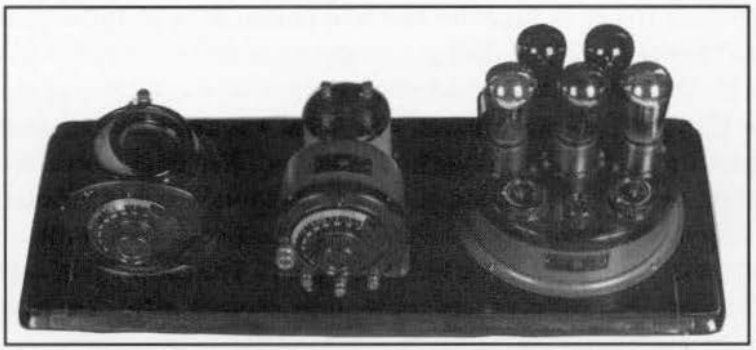


Figure 16. *Model 8. The condenser and fixed coil were added to improve selectivity, but the set was too late to compete. It was never widely sold.*

MODEL 8, No. 4325

The second and directly-related set using the five-tube unit was the Model 8. Kent's engineers addressed the selectivity problem at about this same time with another radio set. Figure 16 shows the second set, Model 8, No. 4325. The Five Tube Amplifier, No. 4330, was identical to that on Model 5. The board for the Model 8 was 10 by 23 inches. This was longer by five inches than that for Model 5, so as to accommodate the No. 4270 tuning condenser and the No. 4326 RF transformer. These two sets were the first to use ten-inch boards, all the previous sets having been built on 8½-inch boards. Model 8 used a Type-11 Tuner, No. 4051 to connect the antenna to the input of the first untuned amplifier stage. Because there was a transformer in that circuit the connection was not simple as on Model 5.

No Model 8 has been found from which the circuit can be traced, and no diagrams were ever published. However, the technology suggests that the Type-11 Tuner was a part of two circuits, one for the antenna, where the Type-11 Tuner was used to resonate the antenna, and the other for the input to the transformer, to provide additional station selectivity. The primary of the RF transformer was probably connected in series with the antenna and the Type-11 Tuner (on its ground end.) The secondary of the transformer was connected across the variable condenser and the input posts of the Five Tube Amplifier. The resonant circuit formed by the transformer secondary and the condenser was tuned to the incoming signal, and thereby adding selectivity.

Model 8 was a compromise between Kent's interest in manufacturing efficiency and the need to discriminate against unwanted signals being picked up by the antennas of the day. It did not effectively solve either problem. With the extra instruments and the length of the board it was

not the desired compact set. The added resonator did not provide enough selectivity to make the comparable to the three-dial sets that would be its competition. It was therefore the last set in the family of fixed-tune radio-frequency amplifier sets. While it had an identity in the factory document system and even got advertised, the Model 8 was not extensively produced. No Model 8 radio (if any was manufactured) has survived.

There were four major variations in that family: Model 6, No. 4052; Model 7, No. 4066; Model 5, No. 4333; and Model 8, No. 4325. With Model 8, the offering of sets using only antenna-input-circuit tuning as the major means of station selection came to an end. Atwater Kent and his technical people had been aware of the need for selectivity before the end of 1922, since another radio was being designed and produced at the same time as the Models 5 and 8 were being experimented with. It was introduced into production on the same day, September 7, 1923. It was Model 10.

MODEL 9, No. 4445

The very short period between November, 1922 when Atwater Kent started to assemble radio receivers, and October, 1923, when the Model 10 was firmly established as a satisfactory product for the American household, saw many changes in the radio circuits offered for general sale. In the radios of nearly all suppliers, tuned-RF amplifiers displaced reflex and regenerative circuits and the broad, fixed-tuned RF amplifiers. Some manufacturers such as AMRAD used variable-inductance instruments in which resonance was provided by the inter-turn and inter-winding stray capacities of the coils. Other manufacturers used variable condensers with fixed coils.

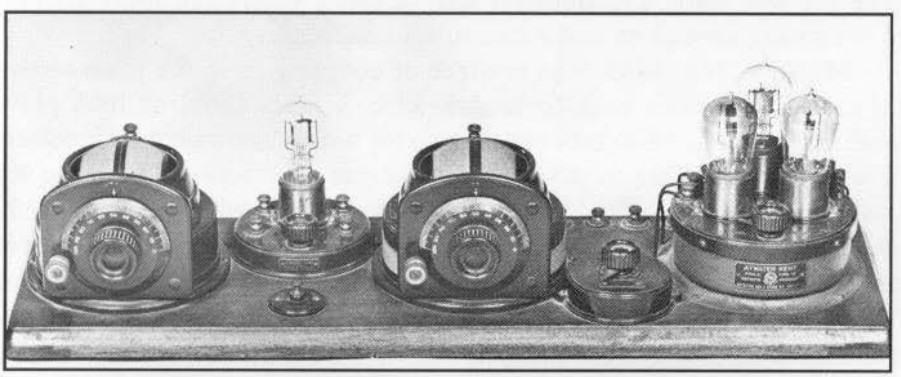


Figure 17. *Model 9, Inductor. Self-resonant variable inductors provided selectivity. Kent used his coil stock to build an improved performance, moderate-cost set.* *Photo: Alan Douglas*

Atwater Kent made sets both ways. The Model 10 sets, described subsequently, used variable condensers. Model 9, No. 4445, Figure 17, used variable coils. The set used a Type-11 Tuner to match its antenna to the input of the radio amplifier and a Coupled Circuit Tuner to connect the radio amplifier to the detector. Both of these instruments were tuned to the frequency of the selected station. Together they provided enough selectivity for almost all uses of the set. The situation for which the Model 9 was not sufficiently selective was when a small station was blanketed by a strong, nearby station only a few divisions away on the dial.

The circuit for the Model 9 (inductor version) was a simple RF amplifier coupled inductively to an antenna and also coupled inductively to the Detector Two Stage AF Amplifier. Everything beyond the Coupled Circuit Tuner was found in the three-tube TA unit. When the Model 9, No. 4445 is compared to Model 6, No. 4052 the result is revealing. The circuit for No. 4052 is identical to No. 4445, the Model 9, except for the interstage transformer. In the earlier set, the transformer was not tunable and as mentioned in the earlier review, the selectivity was poor. It is likely that Atwater Kent's engineers simply used the earlier circuits, adding the variable inductors to improve the selectivity. They knew the earlier set's performance to be acceptable for sensitivity and reliability, and had no difficulty recognizing the value of the tunable interstage transformer.

A characteristic feature of Model 9, No. 4445, is the number of tubes. Although it was designed and released at about the same time as the Model 10 (October, 1923), it used only four tubes. It included a potentiometer to change the RF amplifier bias and thereby change the gain of the radio. The function was that of a primitive volume control. The set was made available for use in cities where the local stations were strong enough to make five tubes unnecessary.

Model 9, No. 4445, was not free of coupling from the plate circuit of the RF amplifier back to its grid circuit. This coupling took place both in the tube and also between the two big tuning instruments. Therefore, it was quite possible to substantially increase the sensitivity in the RF amplifier stage by careful tuning. With a very good tube, not only would the Model 9, No. 4445 regenerate, but it could be made to spill over into oscillation. Thus the Model-9 radio could, under some circumstances, be made more sensitive than a Model 10. Since Kent did not license the regeneration patent from Armstrong, the set could not be offered for extreme sensitivity, nor could any part of Kent's organization issue instructions about the means of raising its sensitivity. It could only be represented as an efficient, reasonably-selective, tunable-RF receiver.

The Coupled Circuit Tuner that was used as a transformer between the RF amplifier and the detector in the Model 9, No. 4445 was unique in the Atwater Kent family of instruments. Close examination of the unit shows two differences between that instrument and the ones that were offered for sale as separate instruments. The bigger difference was in the number of turns in the primary of the Coupled Circuit Tuner used on the set. The outer coil on the radio unit was the primary of the interstage transformer and was therefore the plate load for the amplifier tube. To be the proper load impedance, the coil was wound with 22 turns. On the separate instruments that coil had 35 turns with taps to divide it into sections.

The other difference was that no taps were needed on the radio instrument, and the units were not equipped with all four brass binding posts on the rear apron. Only three were used, although all four bosses were left on the casting. These two minor changes made it practical for Kent to save the cost of a new instrument when he brought out the Model 9, No. 4445.

Model 9, No. 4445, incorporated a potentiometer wired across the filament circuit with its arm connected through the Type-11 Tuner to the grid of the RF amplifier. As with all the other Kent sets of the time, the potentiometer was used to reduce the gain of the RF amplifier. From the present-day performance-verification of restored sets, it appears that the potentiometer was really a regeneration control used in conjunction with careful tuning of both the Coupled Circuit Tuner and the Type-11 tuner.

Model 9, No. 4445, required a more sophisticated tuning procedure than the Model 6, No. 4052, and the Model 7, No. 4066. It was closely akin to the way standard plate-resonator sets were tuned. With the potentiometer holding the tube gain down, the grid and antenna were resonated to the incoming frequency using the Type-11 Tuner. This required a strong signal if it were to be heard in a loudspeaker. Headphones worked well, however. Then the Coupled Circuit Tuner was rotated until the station signal was maximized. By doing this with several stations across the band, the dial could be calibrated for maximum sensitivity without strong regeneration. Then the Coupled Circuit tuner was adjusted to again maximize the signal. Its dial reading was also recorded. For very weak signals, the dials were set at about the readings where the station was expected, and the potentiometer advanced to the oscillation point and backed off slightly. Fine tuning of all three instruments then enabled the set to reach maximum sensitivity on the frequency of the weak station.

A later version of Model 9, No. 4445, was offered on the market about a year after the first version. The early version used a green TA

unit with binding posts at the rear of the board for power. On the later version, the TA unit was finished in a brown-crinkle paint, and power for the set was carried through a cord. The early version was assembled on a board 26½ inches by 8½ inches. Later, the wide board was used and the overall length reduced. That board was 24 inches by 10 inches. The circuits for both sets were the same except for power connections. The layout on the boards differed a little. On the early (green) set, the potentiometer was mounted between the Coupled Circuit Tuner and the TA unit. On the later (brown) set, the potentiometer was mounted between the two variable inductors. Similarly, the switch was moved to complement the potentiometer.

Atwater Kent produced another Open Receiving Set that was also called Model 9, sometimes referred to as a Model 9C. It was No. 4660 and is shown in Figure 18. The set is very similar to the Model 10C, No. 4700. It appeared to be a Model 10C without one RF-amplifier stage. Comparison of the parts lists of both sets shows the same parts were used in both sets except for the board. The Model 9C used a board 20½ inches by 10 inches. As with the Model 10C, the axes of the RF transformers were at right angles to each other, except that the third one on Model 10C (parallel to the long edge of the board) was left off. The board was foreshortened by almost exactly the distance between the centers of the second and third variable condensers, as if the set were a 10C, cut and rejoined without the second radio amplifier.

Among collectors there is a question of whether an earlier Model 9C preceded the No. 4660. No records from the Atwater Kent Manufacturing Company have turned up to identify or describe such a set, but that is by no means conclusive. An early version of the 9C would seem to be a variation of the Radiodyne 10, No. 4340, in the same way that the No. 4660 was derived from the No. 4700. Such a set is to be found in Muchow's Historical Radio Museum. While the set does not have identification tags, it appears to have been assembled and wired by the factory and has nameplates on the coils. The nameplates do not have a name (like "Radiodyne") on the lower left edge and they do not have a number (such as Model 10.) They appear to have been altered by the abrasion of their earlier legend. The radio may well have been built in the factory when the No. 4340 changed from a Radiodyne to a Model 10, and was equipped with Radiodyne nameplates that were changed. A microscopic analysis might show which of the original tags had been modified.

Harold Greenwood thought such a set was built by Atwater Kent. He constructed one as a replica and pictured it in his *Pictorial Album* (the blue book) on page 109. *Vintage Radio* by Morgan McMahon (the pink book) carries the picture on page 75. The Greenwood version of the early Model 9C, with condensers, is now in the author's collection.

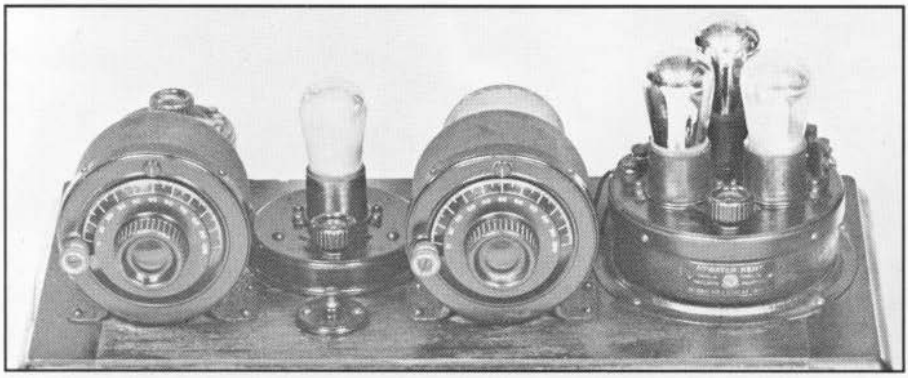


Figure 18. *Model 9, Condenser. Model 10 was a better basis for the moderate cost, moderate-performance radio that was still Kent's quality.*
Photo: Alan Douglas

The board dimensions of the early and late versions of the Model 9C appear to have been the same, but the wiring patterns were quite different. Each followed the layout of its corresponding Model 10. However, a variation between the early 9C and the No. 4340, Model 10, was the omission of the potentiometer on the Model 9C.

Was the early Model 9C a standard factory set? On the negative side stands the lack of factory identification. But on the positive side stand these two sets and the fact that the early Model-9 inductor set was never identified with a unique number. As fast as production must have been going in the factories on Stenton Avenue and on Wissahickon Avenue, there is little doubt that the early versions of both styles of the Model 9 could easily have gotten produced without complete identification. Neither could have been manufactured for more than three months before its successor was put on the market. The author, and also noted collector Ralph Muchow, think that all four sets were produced by the factory.

Chapter 4

THE MODEL TEN SERIES

"RADIODYNE" AND MODEL 10

Prior to mid-1923 broadcast stations were generally assigned the frequency of 833 kHz, more commonly identified as 360-meters wavelength. They shared their time on the air in any particular area. But the limited air time per station led to a reassignment of frequencies to permit simultaneous operation of stations without interference. By the time that the 4000 series was made obsolete by the need to assign more than two wavelengths for general broadcasting (September, 1923) the count of licensed stations in the United States and Canada exceeded 550. The total number of receivers was well over one million. Of these Atwater Kent had sold only a very few (estimated as less than 25,000) and the newest ones were obsolete. He recognized the market and what he had to do to increase his share substantially.

The need for selectivity meant more tuned circuits. Overall receiver output demanded by the listening public meant loudspeaker reception. Receiver input was determined by transmitter power and by the antennas used for transmission and reception. In 1923 the primary coverage area of radio stations was not clearly defined. The art and science of broadcasting was too new for standards of signal strength and transmitter power to have evolved. Overall receiver gain had to exceed ten thousand, and consequently five stages were necessary. Grid-leak detector limitations pointed directly to two RF amplifiers and two AF amplifiers.

With the exception of the tuned circuits, this was the configuration of the unsatisfactory No. 4066. A major engineering and manufacturing improvement was needed—a changing of the tuned circuits from the self-resonant inductors typified by the Type-11 Tuner, to the variable condenser-coil combination found on the Model 8. Prior to 1920 variable condensers were usually complex, expensive, precision mechanical devices. The idea of rotating a set of fixed plates had been developed along with sliding plates, cylinders and other styles. However, the factory tooling necessary for mass production, with its consequent price reduction was not justified by the expected market for variable condensers until the growth of the broadcast radio provided a large market. Suppliers of

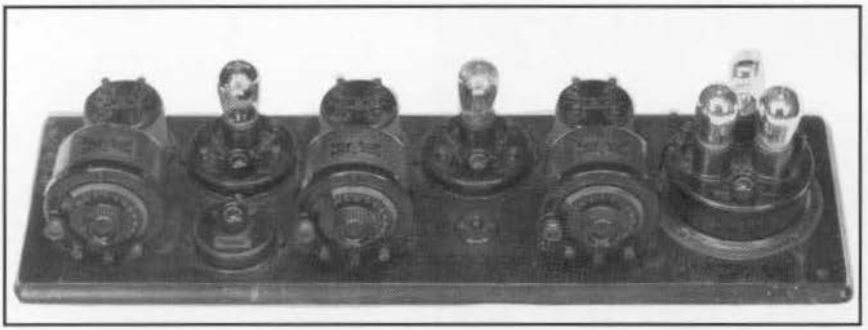


Figure 19. *Radiodyne. This radio, with its three turned circuits and five tubes, made all the foregoing sets obsolete.*

home radio equipment, therefore, started with variable inductors. When the large market for tuning circuits that resulted from the need for selectivity demanded condensers, many manufacturers, including Atwater Kent, designed and produced them. They made condensers the basis of multi-dial, tuned-radio-frequency receivers.

Atwater Kent's next open set, No. 4340, Figure 19, incorporated three tunable, resonant circuits and fixed the problem. The new instruments developed for the No. 4340 were a variable condenser and a radio transformer (RF coil). The condenser, No. 4270, carried the familiar hallmarks of Atwater Kent's mechanical designs, the deep-drawn steel container and the beautifully cast Bakelite face and dial. The color of the containers was carried over from the original line of instruments, a light green-khaki that the literature called gray. The transformer was a straight-forward, single-layer solenoid that included a smaller hexagonal primary coil inside the cast Bakelite form. Both the condenser and the transformer used binding posts for connection into the rest of the circuit. Both also carried nameplates. Altogether the polished brass of the nameplates and the binding posts that set off the shiny Bakelite and the green paint, above the highly finished board, gave the set a very striking appearance. Compared to the dull rectangular boxes that were offered by some of the competition, the Atwater Kent set had the real sales potential of strong visual appeal.

The transformer (coil) nameplates on the first No. 4340 tell an interesting story. They were marked along the lower edge (left side), with the word "Radiodyne". Figure 20 shows a coil with the nameplate from a Radiodyne. The introductory Atwater Kent advertising material of the time used that name to identify the receiver, so it seems reasonable to assume that Atwater Kent had chosen the name for the new line. But trouble developed because the Western Coil Co. of Racine, Wisconsin had previously established their right to the name. No information has

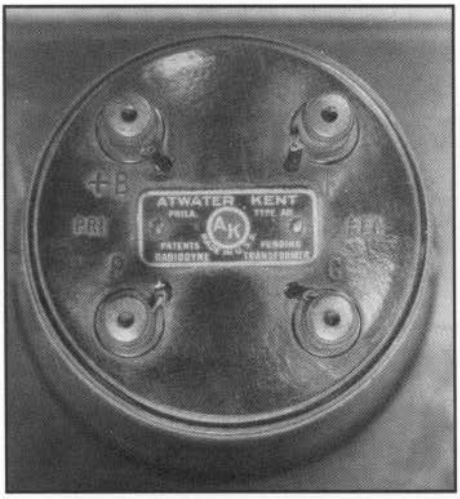


Figure 20. *Radiodyne Nameplate. All Kent had to do to change to Model 10 was alter the word Radiodyne on the lower left of the nameplate.*

come to light about what must have happened around the factory when that piece of bad news hit Stenton Avenue, but only a little imagination is required to picture Mr. Kent's response since he was known to be an impatient perfectionist.

While there is no direct evidence about what happened next, the story can be pieced together from the radios that have survived to the present. Quite a few green No. 4340 sets, with the same binding posts and nameplates similar to those on the Radiodyne, may be found in present-day collections. However, they differ in one important detail from the first set: the name plates on their transformers carry the legend "Model 10" in place of the word "Radiodyne." They are the No. 4340s that were produced after the Radiodyne name was discontinued and were referred to in the dealer and the public advertising as Model 10.

From the time of their introduction, the No. 4340 open sets (both Radiodyne and Model 10) sold very well. Therefore, the pressure to change the nameplates must have been intense. How intense is indicated by another No. 4340 set that has come to light. It tells what was done in the interim until the photo-etcher had the new nameplates ready. The transformers on that set carry the same nameplates as were used on the single-tube sockets and on the potentiometer. They are marked "Atwater Kent, Phila., Patent Pending". Production was carried on, without a break, while the Radiodyne transformers that had been finished were altered to use the interim nameplates, and in turn, these were used to replace the transformers on assembled and in-process sets. The production rate approximated 1000 sets per week, so perhaps only 100 of the interim sets were released.

The Model 10 Radiodyne is pictured in Figure 19. Arranged on the board, from left to right, are the three resonant tuning circuits, the left-most being the input or antenna stage. The RF amplifier tubes were located

between the tuning stages, with tube sockets similar to those used on earlier sets. Each contained its own rheostat. On the right was the familiar three-tube unit containing the detector and AF amplifiers.

The axes of the coils on the Radiodyne were parallel to each other and perpendicular to the board. Each coil was a transformer having a primary of about six turns wound inside the main coil form. All winding leads were brought up to binding posts on the top of the coil where they were connected to the under-board wiring by means of wires brought up inside the coil. In a similar manner, wires from the under-side of the board were brought up to binding posts on the front panels of the tuning condensers. The under-board wiring connected the condensers across the secondary coils on the RF transformers, thereby enabling the user to resonate each stage to the frequency of the incoming signal. Another identifying feature of the Radiodyne is the connection from the underboard to the tube sockets. Again, the wiring comes up through holes in the board (and the socket panels) to binding posts on the top of the socket body.

In a factory producing a standard line of products, such as the three-dial receiver, there will be minor changes and improvements introduced from time to time. If two sets come out with only one difference between them, the reason for the change is usually clear from the change itself. Several such examples in the Model 10 series will be cited as they arise in considering the total series of Model 10 receivers. In the case of the name, however, the reason was neither improvement nor reduced cost. It was important enough to justify immediate introduction. A possible trademark infringement was that important.

The Model 10 continued the open-set construction and wiring practices of earlier Atwater Kent receivers. The first three sets in the 10 Series used the gray (green) color for the metal cans and were built on boards 10 inches deep by 31½ inches wide. Figure 21 shows the underside of the Model 10. It is included to give the collector a means of deciding

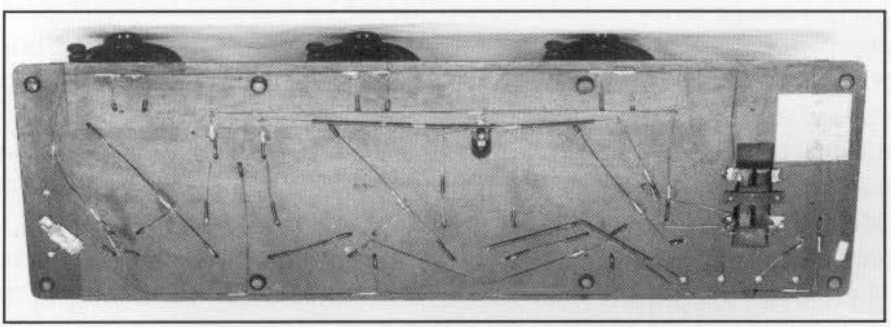


Figure 21. *Model 10, Under board Wiring. Kent's standard wiring is illustrated by the runs in this picture. Sensitive wires were enclosed in spaghetti.*

how much change has been worked on his set if it deviates from the factory look — as so many do. In the illustration, the condensers on the right side are not the originals, which were encased paper cylinders with a black outer covering. They are replacements, probably required because moisture attacked the originals. The plate-supply filter condenser was always in series with the filament by-pass condenser across the combination of the A and B batteries. This was true whether the set was on or off. If those condensers got electrically leaky (and they did, very easily, when moisture got into them) they discharged the expensive B batteries even when the set was off unless the owner disconnected them.

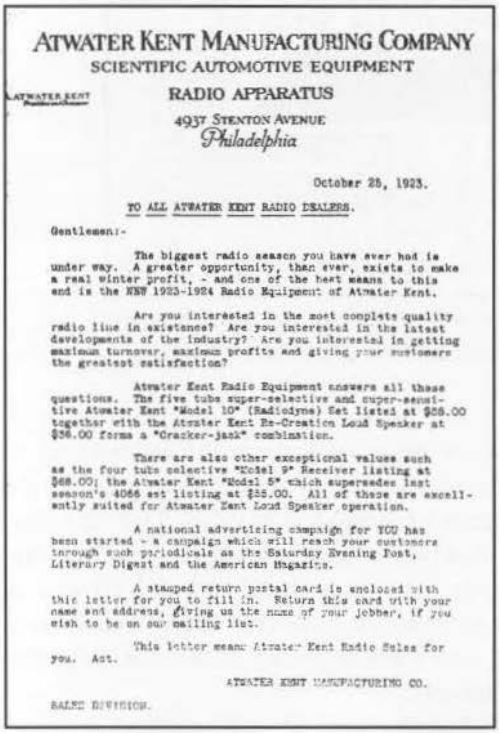
In the illustration the identifying tags that were used by the factory and the sales organization to account for production are shown. They were made of paper and glued to the underside of the board. The more familiar tacked tags had not come into use at the time of the first Model 10. The larger tag carried the serial number of the set as well as warranty information.

Model 10 offered a great improvement over the earlier open sets produced by Atwater Kent. It was well suited to its job of amplifying the moderate broadcast signals of 1923 to loudspeaker volume for family listening. The reason for its effectiveness was the addition of tuned RF amplifiers to the detector two-stage amplifiers of the earlier sets.

FACTORY SUCCESS

The introduction of the Model 10 0pen Receiving Set by Atwater Kent in the fall of 1923 turned out very successfully for the company. The internal release date was September 23, 1923, with announcement to the dealers late in October. The announcement letter is reproduced in Figure 22. In the letter the newest was identified as both Model 10 and Radiodyne, and given strong emphasis over the Model 9 and the Model 5. Clearly the company had plans to use both designations for the new set.

The timing of the introduction of Model 10 was doubtless influenced strongly by the retooling of the factory to produce the tuned-RF amplifier design. The biggest change was the radio-frequency transformer. Not only did the electrical and mechanical details of the coil have to be established but the arrangement of the circuits had to be carefully chosen to provide maximum amplification without objectionable sensitivity to regeneration (spillover) and hand-capacity effects. The potentiometer was used to keep the amplifier tube gain under control. Coupling effects through the tubes and between coils were the difficult problem. The fastening of the instruments and the placing and connection of the under-board wiring could no longer be variable from set to set as it had been with earlier



ATWATER KENT MANUFACTURING COMPANY
SCIENTIFIC AUTOMOTIVE EQUIPMENT
ATWATER KENT
RADIO APPARATUS
4937 STENTON AVENUE
Philadelphia

October 25, 1923.

TO ALL ATWATER KENT RADIO DEALERS.

Gentlemen:-

The biggest radio season you have ever had is under way. A greater opportunity, than ever, exists to make a real winter profit, - and one of the best means to this end is the NEW 1923-1924 Radio Equipment of Atwater Kent.

Are you interested in the most complete quality radio line in existence? Are you interested in the latest developments of the industry? Are you interested in getting maximum turnover, maximum profits and giving your customers the greatest satisfaction?

Atwater Kent Radio Equipment answers all these questions. The five tube super-selective and super-sensitive Atwater Kent "Model 10" (Radiodyne) Set listed at $265.00 together with the Atwater Kent Re-Creation Loud Speaker at $36.00 forms a "Cracker-jack" combination.

There are also other exceptional values such as the four tube selective "Model 9" Receiver listing at $88.00; the Atwater Kent "Model 5" which supersedes last season's 4066 set listing at $55.00. All of these are excellently suited for Atwater Kent Loud Speaker operation.

A national advertising campaign for YOU has been started - a campaign which will reach your customers through such periodicals as the Saturday Evening Post, Literary Digest and the American Magazine.

A stamped return postal card is enclosed with this letter for you to fill in. Return this card with your name and address, giving us the name of your jobber, if you wish to be on our mailing list.

This letter means Atwater Kent Radio Sales for you. Act.

ATWATER KENT MANUFACTURING CO.

SALES DIVISION.

Figure 22. *Announcement. The Radiodyne was widely heralded as the beginning of a new era of radio.*

sets. Defined assembly practice and quality control had to be initiated. The factory had to be reorganized for progressive assembly under rigidly controlled conditions.

One wonders if the primary reason for the chosen release time wasn't the upcoming holiday season. With radio propagation conditions showing a great improvement from summer to winter, and with the custom of the American people to go from outside to parlor activities as the weather grew cold, introduction of a new set to coincide with the anticipation of the 1923 Christmas Season was especially desirable. Much of the radio advertising of the time indicates that such factors were important in radio selling.

Figure 23 reproduces a portion of a release from one of Atwater Kent's distributors to his dealers about the Radiodyne. In it, the announcement date is given as November (consistent with the letter's date) and the degree of acceptance of the "Wonder Set" is indicated. The mention of the number of sets back-logged by the factory (21,000 in December) may be taken, not so much as an accurate count, but as an indication of acceptance by the public. It is not inconsistent with the figures in the release for dealer sales when it is remembered that there was an extensive distributor/dealer organization well established throughout the country.



Figure 23. *The Wonder Set. Distributors and dealers were quick to realize and benefit from the new high-selectivity radios.*

Another fact to be taken into account in looking at the acceptance of the Model 10 is that, when compared to other Atwater Kent radios, the Model 10 was an excellent performer. Compared to other TRF sets that were also newly introduced to the market such as Eagle, FADA, and Freed Eisemann, it was competitive. Atwater Kent's Model 10 was in their class for performance while meeting or bettering their prices. It is small wonder that Atwater Kent and his Company entered a new and greatly expanded phase of the business.

The letter in Figure 22 gave the Atwater Kent Manufacturing Company address as 4937 Stenton Avenue. This was a location in the Germantown section of Philadelphia where Kent produced radio instruments and automotive electrical parts and systems in the early twenties. Other advertising material gave the address as 4943 Stenton Avenue, and still other material used 4947 Stenton Avenue. Those addresses were really a complex of buildings into which the company expanded as its production grew. The Stenton Avenue location was first used by Atwater Kent in 1914 when the manufacture of automotive electrical products outgrew the facilities in downtown Philadelphia.

In the written material about the "Wonder Set," two factories were mentioned. One of them was the Stenton Avenue plant. The other was a new factory being constructed on Wissahickon Avenue at about the 4700 block. The need for both manufacturing facilities was borne out by the production records for 1923 and 1924. From the introduction of Model 10 until the end of 1923, over twelve thousand No. 4340 Model 10 receivers were produced. As will be detailed below, there were also twelve hundred No. 4600 Model 10 sets produced in the same period. Together these amounted to nearly 150 sets per day—a very large number considering the style of assembly and the amount of hand work in mounting the instruments and fastening the under-board wiring.

Another change that took place during the production of the Model 10 suggests that a new manufacturing facility was brought on line. The

evidences for this conjecture are two; radio transformers with decorative rings cast into their tops that supplemented the earlier ones with the binding post bosses, and the general arrangement of the under-board wiring that changed from a slightly curved form to a rigidly rectilinear pattern. With production rising, the molding machines and the assembly lines would have had to increase their rates. An upper limit would have been reached where all the available machine time was used to complete a process, such as curing the phenolic.

When that happened, more machines had to be put on line to continue the climb, and the new machines and lines would have required additional space. Initially, this growth was accommodated by changing the Stenton Avenue buildings, which were used earlier for automotive-electrical manufacturing, to radio production. While no direct evidence exists to prove this conjecture, the reduction in advertising of the automotive line coincides roughly with the Model 10 production period. Further increase in the production rates required the new factory on Wissahickon Avenue.

NO. 4600 AND VARIATIONS OF MODEL 10

One more change took place during the manufacture of Model 10. The brown color that became familiar in later open sets and in the panels of the box sets was introduced. This time, however, the part number of the set was changed. The new set became No. 4600 but it was still a Model 10. No. 4600 was equipped with the new style radio transformers and of course, had no binding posts on the condensers, coils and radio tube sockets. It was, however, the last of the Model 10 family to use binding posts for connecting the wires for A and B power.

In the text of the release about the "Wonder Set" mention is made of black and brown sets in addition to the gray (green) one. The question arises whether or not a black or a brown Radiodyne (the name to be found on the coil nameplates) was produced. The author thinks that because the Radiodyne name was abruptly discarded only gray (green) sets were distributed.

Another reason to think that there were no black or brown Radiodynes was the pressure to produce radios. Making style changes was not nearly as important as increasing the production rate of the green sets. This tended to mark the receivers as being produced later, and as it turned out after the discard of the name "Radiodyne." The black set came out using the same coil forms, with bosses for the posts, but without the screws and knurled nuts. Similarly, the condenser panels carried the bosses and markings but were not drilled for the screws and knurled nuts.

At the same time as gray (green) and black Model 10 sets with bosses on the coils and condensers were being assembled, demand exceeded the production rate of the molding facilities using the original molds. New molding facilities had to be put into service. Since the bosses on the coils were no longer required, the new coil dies were cut with a decorative ring in their place. The new dies for the condenser panel were changed only to the extent of continuing the pattern all the way round the face, eliminating the bosses.

The new machines were used to produce phenolic parts right along with the old ones. Therefore, collectors can find many variations of the Model 10. Some had coil bosses; some had coil rings; some had condenser bosses; and some had none. Moreover, these variations occurred on sets with gray (green) instruments and on sets with black instruments. These are all in addition to the Radiodyne and the Model 10 with binding posts.

"Model 10" was used by the Atwater Kent Manufacturing Co. as a brand name for No. 4340. It was the first of a long line of radios that used model numbers as their names. While Models 5, 8, and 9 had lower numbers than Model 10, they were introduced into production later, even though their designs may have been initiated before No. 4340. Model 10 was also used to identify the production radio in the factory even though the more customary method was to use the part number, Part No. 4340.

Neither of these nomenclatures was sufficient, however, to provide a unique identification, since many changes took place in the specific configuration of the No. 4340 receiver without causing a change in the numbers. One very obvious change was the color. In addition to the green set, a black crinkle-finish radio was made. Perhaps the reason for not assigning new numbers was that the production rate had all but swamped the still growing facilities and that part of the staff concerned with documentation and service hadn't become aware of the size of their problem. Most of the changes that took place in the four months or so of the Model 10 assembly were cost reductions that only made minor alterations in the set's appearance, and were not deemed worth implementing new documentation for such a short production run.

One of the changes that was made to the Model 10, No. 4340, was truly a cost reduction. The binding posts on the coils, condensers and RF tube sockets were eliminated. In doing restoration of Atwater Kent radios from the early days, most collectors find themselves looking for the unique knurled binding post nuts that are so characteristic of Atwater Kent breadboards. Several collectors who have checked screw machine shops to get prices for providing a modern supply are shocked to be quoted prices such as $500.00 per thousand, in quantity. Where the

fine knurl is emphasized, the price usually goes up still further. Those binding posts, while costing much less seventy-five years ago, were still expensive compared to other elements in the radio.

By eliminating the four posts on each coil and bringing the coil wires through the board to be soldered directly to the under-board wiring, Atwater Kent was able to save the cost of the screw, the flat lock nut and the dress-knurled nut on twelve binding posts. The retail price of those parts quoted in a 1928 replacement parts catalog was 17 cents per binding post. The factory cost was perhaps one quarter of the sale price or about four cents. Therefore, the coils alone represented about a fifty cent cost saving in the factory. For the whole set, the removal of the tube socket and condenser binding posts as well as those on the coils (a total of thirty-three), resulted in a cost reduction of perhaps one dollar. Based upon a cost for the set at the factory of about one-half of the $100 selling price, the saving was 2%, no insignificant amount as factory practice both then and now will attest. The removal of the binding posts seems to have been made at one production point because, so far, no No. 4340 has turned up with some, but not all of the binding-post changes. Nevertheless, the changes resulted in four green and two black variations.

Although the cost was reduced by these factory changes, the price was held constant. An average worker, in 1923, would have had difficulty in buying a Model 10 with its speaker, batteries and antenna. The average income of the middle-class wage earner was about $1200.00 per year. For comparison, the total price of the Model 10 was nearly $200 when all the accessories were included. Tubes were sold separately, as was the speaker and the source of power. With tubes at $6.00 each, a speaker costing $35.00, an A battery costing $10.00 and the necessary aerial and ground wires and fittings, the total price for a Model 10 radio would have been two months pay.

In addition to this initial outlay, the set user had relatively high operating costs. Recharging the A battery was reasonable at 25 to 50 cents per charge, but B batteries were a high continuing cost that could easily have amounted to 10 cents per night of listening. The time of the A and B eliminators had not yet come. Consequently, the Model 10 was not the radio for the average American household when it was first introduced.

Some collectors have asked about identifying the different Model 10, No. 4340 Open Sets. The required features are color, connections and instrument characteristics. Up to and including the Radiodyne and the Model 10 direct replacement set, the metal cans in which instruments were made were painted the green color which the Kent literature referred to as gray. These were the condensers and the TA Detector, Two Stage Amplifier. All the plastic (phenolic) parts were brown and the exposed

metal parts were of lacquered brass. Sets after the Radiodyne replacement were reduced in cost by removing binding post from the tube sockets, the coils and the condensers, and later by being painted black.

For the later Model 10, 4340 sets, there were two styles of radio transformers (coils). One showed the four bosses that had been used with the binding posts. For sets without binding posts the bosses were not pierced. The other style replaced the bosses with a ring that enclosed the nameplate. Both of these styles were carried into the Model 10A. The author thinks the ringed coils were cast in the new assembly facility while the coil forms with bosses were made in the original assembly plant. The nameplate does not prove the set to be a Model 10 since the nameplates were found on the Model 10A. Proof of identity for the Radiodyne is, however, established by the nameplate.

Another difficulty arises in identifying the Model 10, No. 4340 Open Sets that vary from this rigid set of descriptors. The factory used Model 10 for identification until it introduced sets without the battery terminal binding posts. These were Model 10A sets. Model 10 is not known to have a power cord. Conversely, all Model 10 Open Sets were equipped with binding posts for power. To complicate matters still further, a brown set which used the coil with rings was produced, starting in late 1923. It was also a Model 10, but not a No. 4340. Its part number was 4600. The release date was February 22, 1924, but production records show the set being assembled in 1923 as well as 1924. This minor inconsistency may be an error or may only reveal a quirk in the release date system.

The details of the construction of No. 4600 were almost identical to the black and green sets. Its wiring was greatly improved over the early sets. It represents the last of the Model 10 series, and has the best under-

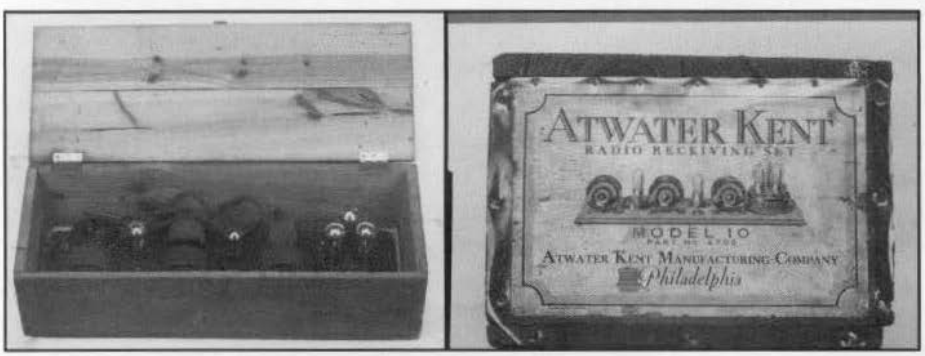


Figure 24 (above, left). *Model 10 Shipping Box. Protection of the set during the harsh environment of shipping resulted in a full wooden enclosure.*
Figure 24A (above, right). *Set Identification on Box. The label on the right end of the shipping box made it easy to identify the sets in stock when they were stacked.*

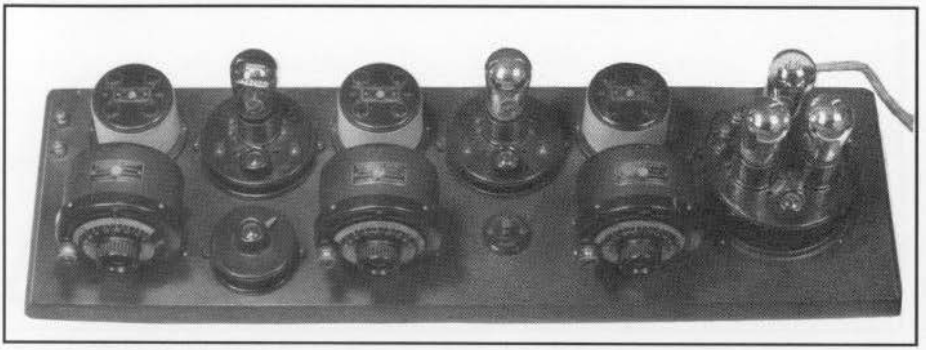


Figure 25. *Model 10A. Kent used sales results and engineering experience to reduce costs. Notice the removal of the expensive binding posts from this set.*

board wiring in the series. The set number for this radio was ink-stamped on the tag underneath the board. These tags were used before the forms including the part number came into use.

The factory tabulation of produced Model 10 radios lists two more sets. One is No. 4490, described as "Model 10 in 4217 cabinet with cable". The other is No. 4540, "Model 10 in console with cable". Whether these are 4340 style sets, with terminals but with a cable built into the enclosure, or later sets that were equipped with cables (Model 10A, No. 4550 or No. 4560) was not indicated. The later sets were offered by Pooley but no indication of the earlier set in a Pooley cabinet has come to light. An early picture of a cabinet set shows binding posts on the condensers suggesting that the No. 4217 cabinet used the 4340 style Model 10 radio with a board that had been cut with square edges. This resulted in the radio being given a different part number.

MODELS 10A AND 10B

By the beginning of 1924 the market acceptance of the Model 10 Open Set proved that Atwater Kent had entered the market with the right product. The next tasks for the factory were further expansion of production and the introduction of new features that would assure continuing sales growth. During the year a new plant that was large enough for growth far beyond the Open Sets was built on Wissahickon Avenue in Germantown, a part of Philadelphia.

Radio receiver manufacturers of the early twenties realized very quickly that their market was cyclic, with heavy buying in the late fall and early winter. Spring and summer were not so much the time for major sales as for planning new models and building up inventory. Atwater Kent had clearly recognized his market, pursuing it with the introduction of Model 10A at the beginning of the 1923/1924 holiday season.

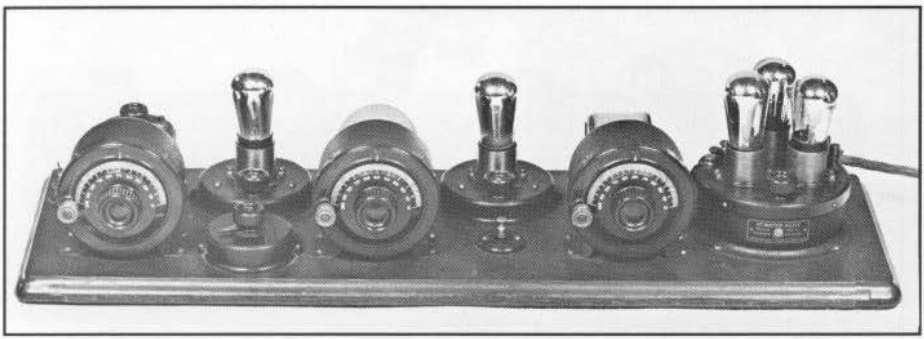


Figure 26. *Model 10B. Orthogonal coils reduced the interstage feedback and let the customer use more of the radio's amplification.*
Photo: Alan Douglas

To a casual observer there appears to be little difference between a Model 10 and a Model 10A. Of course each has its own part number, No. 4340 (or No. 4600) for Model 10, and No. 4550 or No. 4560 for Model 10A; but until a collector gets deeply into them, the part numbers mean little. The major difference that separated the 10 from the 10A was the power cord. Model 10 used binding posts for the A and B power connections. Model 10A and all subsequent sets used a power cable, making it far more convenient to connect the batteries that were needed for its operation. Adding the cable resulted not only in assigning a new part number, but also in adding a suffix letter to the model number. The changed set was No. 4550 if the painted instruments were colored brown, and No. 4560 for black. Receivers of either color were called Model 10A. The gray (green) color was not used for Model 10A.

Improvement of the radios was accomplished by continuing the changes that started with the removal of the binding posts on Model 10. Figure 25 shows the Model 10A. On the set illustrated the binding post bosses may be seen on the radio transformers, but other sets came from the factory with decorative rings on the coil forms in place of the bosses. This suggests that the two facilities that were used for Model 10 production continued to assemble Model 10A open sets.

The practice of making minor appearance alterations without changing the identification numbers continued. Such variations included eliminating the nameplates from the tuning condensers and coil forms and removing the separate ground connection binding-post on the left edge of the board. The number of variations of Model 10A that could be found in present-day collections approaches sixteen when color, bosses, nameplates and ground binding posts are reckoned. In other details, the 10 and the 10A were similar: both had three radio-frequency transformers with parallel axes; both incorporated potentiometers for adjusting the performance of

the receiver; and both were produced with black and brown wrinkle-painted metal condenser and TA-unit cans.

Upon examination of these sets in the author's collection, the wiring under the board of a No. 4550 (the brown set) was found identical to the way the wires were arranged under the No. 4600, the brown set in the Model 10 group, with the exception of the power cable. The wiring arrangement of a black set, No. 4560, was quite different from the brown set, but bears a strong resemblance to the black set in the Model 10 series.

Review of Model 10A sets that have survived since their introduction (December, 1923 for No. 4550 and January, 1924 for No. 4560) reveals two versions. The earlier sets had nameplates on the coils and the condensers but sometime in the early part of 1924 these were eliminated from both the black and the brown sets. The dates or serial numbers of the sets at the time of the change are not recorded anywhere but can be bracketed between March and May of 1924. Doubtless the removal of nameplates was another change to reduce cost. The six pieces must have cost half a dollar in total, with another half a dollar for drilling and riveting the instruments.

In the beginning, the nameplates added an image of identification and certification to the receivers and therefore had strong sales appeal. With increasing acceptance of Open Sets for their performance by the public, the nameplates no longer justified their cost. As with the binding posts on the Model 10, the removal of nameplates on the 10A added substantially to the profit margin on the receiver.

Comparison of the wiring of black 10A, No. 4560s of both the early and late production shows identical wiring arrangements. Similarly, a comparison of brown 10A, No. 4550s shows identical arrangement of the under-board wiring, but it is different from the wiring of the black 10A. This strongly suggests that the brown sets were made in one factory and the black sets in another. In the announcement about the Radiodyne mention was made of additional production facilities in a new factory. The new space was the Wissahickon Avenue factory and that the implied old factory was on Stenton Avenue.

Could the brown set have been started in Wissahickon Avenue and the green sets and the black sets assembled at Stenton Avenue? Support for this idea comes from many directions. First is the difference in wiring arrangement. In a production shop, the tendency is strong to prohibit variations in accomplishing the work to be done. Uniformity leads to increased reliability and fewer mistakes. (The fact that it also leads to drudgery and negative labor attitude had yet to be learned by industrial management in 1924.) At the same time a new production run or a new assembly line offers an excellent opportunity to introduce improvements.

The Wissahickon operation was such an opportunity. Second, the efficiency of stocking the colored instruments separately could have been greatly enhanced by having all the brown instruments away from the earlier stocks of green and black instruments. The separation of factories would have carried this out perfectly. Third, the similarity of the wiring of later black sets in the 10B series to the black sets in the 10A series, as well as the similarity of the 10A black sets to the black sets in the 10 series, suggests they were all assembled on the same line over a continuous period, with only minor changes being introduced for each new model. The idea seems to check using the author's collection as the basis, and it tends to accord with efficient factory practice as seen from the time of the twenties.

Production of the Model 10A set must have continued at maximum rates in both factories since the coil forms with and without nameplates were molded in the old style with bosses (formerly used for binding posts), and in the new style with decorative rings. The author suggests that the coils with rings were used on brown sets assembled in the new factory and the coils with bosses were used only on black sets which were made at Stenton Avenue.

During the time that the Model 10A was produced, Atwater Kent engineers were busy on a problem in both the 10 and the 10A. It was the limitation of radio-frequency amplification caused by feedback in the amplifier stages, which could result in oscillation in one or the other of the two radio-frequency amplifiers. The tendency for the radio-amplifier section of three-dial radios to oscillate was closely related to several factors, namely tube amplification, inter-electrode capacity, and inter-coil geometry. For the next set in the product line, Model 10B, shown in Figure 26, Kent's engineers kept the potentiometer to control radio-frequency amplifier tube gain and rotated the transformers to orthogonal positions to reduce the magnetic coupling between them. They did nothing about the capacity coupling in the tubes, so the set was still difficult to use when maximum sensitivity was desired. Kent might have felt that his receivers did not need this much amplification, perhaps because his customers wanted sets for entertainment and education rather than for DX (distance) chasing.

Because elimination of the magnetic coupling between the radio-frequency transformers was chosen as the solution, the second and third coil forms were redesigned for orthogonal mounting. This is the difference between 10A and 10B. The first coil, the antenna transformer, was left with its axis vertical but had a switch installed on its top. The switch selected different numbers of turns to put in series with the antenna. The coils on the Model 10B were apparently formed using the same molds as

before the change of orientation. The reason for this conjecture is the continued presence of the bosses or rings on one end of the coils. Both decorative-ring coils and boss-end coils were used on the Model 10B sets. There did not seem to be a direct relationship between the style of coils and the color of the set since surviving sets show all combinations.

Did Atwater Kent's production people use the same casting molds for the second and third transformers on the Model 10B as they had for the 10A? The difference in the molds is in the expanded ring at the bottom of the 10A forms that was used to fasten them to the board. On the 10B the forms simply end about 1/4 inch beyond the winding. Trimming the 10A forms would have been very simple although it was an additional operation. Using new molds would have been cheaper if the cost of the new molds was neglected. Another factor pointing to using the old forms is the drilling of two holes in the boss/ring end for the mounting foot. The author thinks the old molds were continued in use.

The popularity of the three-dialer in the mid-1920s came not so much from its small-signal performance as from its easy use by a family listening to the broad range of programs being offered by the highly-competitive broadcasters. The Model 10B was probably an improvement over the Model 10A, but comparisons made on surviving sets do not show a clear difference. The Model 10B was offered in the same colors as the earlier sets, black and brown. The black set was still identified as No. 4560, and the brown one as No. 4550. Models 10A and 10B were introduced early in 1924, but were produced for only a little more than half a year, when they were replaced by Model 10C. The production rate by this time had reached almost 5000 sets per month.

MODEL 10C, No. 4700

Atwater Kent manufactured a very substantial number of Model 10 Open Receiving Sets (versions A, B, and C) in the three years that they were the main products of his factories. Four versions were produced, three of which were described earlier. This segment reviews the fourth, Model 10C, No. 4700, introduced May 29, 1924. The designation 10C for the last of the five-tube tuned-radio-frequency (TRF) amplifier Open Receiving sets was used in some of the factory documents but not in the advertising and descriptive material of the time. Most collectors prefer to use Model 10C for the No. 4700 to aid in distinguishing it from its predecessors.

Significant changes were made in designing and producing the Model 10C, No. 4700, Figure 27. The potentiometer was eliminated. This was the primary differentiating mark between the Model 10C and all the

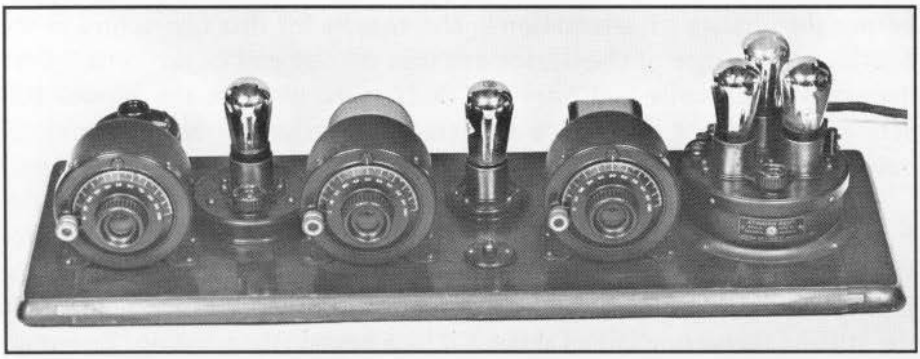


Figure 27. *Model 10C. Another improvement carried forward from earlier sets. The potentiometer was eliminated.* *Photo: Alan Douglas*

other Model 10 radios. The function of the potentiometer in earlier sets was adjustment of the RF-amplifier grid bias. This reduced the gain of the amplifiers so as to avoid excessive regeneration in those stages. Atwater Kent might have used the Hazeltine method of controlling regeneration but instead, in the earlier Model 10s, he provided the potentiometer for reducing amplifier gain. The competitive performance of those sets suffered because of the lesser sensitivity as compared with the Neutrodyne circuits when the bias was adjusted to compensate for their strong tendency to oscillate.

In order to recover sensitivity without excessive regeneration, Atwater Kent added damper resistors in series with the amplifier grids. Their value was chosen to be about 800 ohms. The potentiometer was no longer needed so Kent was able to effect another cost reduction by its elimination. The damper resistors reduced selectivity a little but this was not noticeable in the normal operation of the set. From a purely cost standpoint, the advantage was with the dampers, but for uniform sensitivity over the broadcast band, the Neutrodyne system was far superior. The damping circuits in Model 10C were carried forward for more than three years, even after type-226 tubes replaced the type-201As and the sets became house-powered metal boxes.

Changing the grid circuits permitted the deletion of the potentiometer on the Open Sets. The cost reduction was worthwhile, but there was another benefit. Without the potentiometer, the spacing between the first and second tuning condensers could be reduced. Another change that saved costs and permitted closer spacing was replacing the second TRF amplifier tube socket with a simpler unit that had no rheostat. The filament was paralleled with the first tube so that both were controlled from the rheostat on the first tube socket. The standard Model 10C, No. 4700 was reduced in board size by two inches. This last change

was probably not so much a cost reduction as an improvement in the aesthetic appearance of the set. The distance between the tuning condensers was reduced from nine inches to eight inches so that the balanced appearance of the set was maintained.

A close comparison of Model 10C with the earlier sets reveals several additional changes. The by-pass condenser on the RF amplifier filaments was eliminated in the Model 10C and the plate voltage on all the tubes (except the detector) was made the same. The latter change amounted to raising the RF plate voltage from 60 to 90 volts.

Model 10C was produced with several variants. The coil forms used for the RF transformers showed both the decorative ring style and the bosses style as did all the earlier Model 10 radios. However, on all the 10C sets the transformers utilized end covers. The cover was a cost increase, probably justified by the protection it gave to the primary coil inside the form. Model 10C was also produced as a compact. The No. 4700 designation was used for the smaller set as well as the standard 10C. Careful comparison shows the small, squeezed-together appearance of the smaller board. It is three inches shorter than the standard 10C-board length of 29 inches. Both are 10 inches deep. The ends of the compact board were treated differently to reduce warping and the effects of age on its appearance. On the standard 10C, the board had end pieces two inches wide, grooved to fit on each end of the main board in the fashion of all the earlier Atwater Kent boards. The compact 10C did not use the end pieces, instead having a re-enforcing strip about one inch wide inserted in a groove at the end of the main board.

In working on the Model 10 sets, be they the ones from the first production (the ones without power cords) or the Model 10As and Bs, or the last of the group, the 10C sets, the most common problem is the audio system. Nearly all the audio transformers used in early broadcast receivers were plagued with open windings. At first it was thought that the problem was caused by flux corrosion and faulty stripping of the enamel insulation, prior to making the original terminal connections. While some open windings were due to faulty manufacture, many others were not. Another cause might have been shorts developed in the amplifier tubes where the plate supply was grounded through the tube. The excessive current could burn the winding open. Again, this was a possible cause but still not a satisfactory answer, particularly for open grid-circuit windings.

Another explanation, and one that fits minute examination of typical failed joints, is that the copper wire has been dissolved by the tin in the solder at the joint. As a result, a crystallized interface between the parent copper and the pure solder has formed. Under the thermal stresses of passing years, this interface becomes electrically non-conductive.

There are two situations where this effect is especially bothersome. One is familiar to all Atwater Kent restorers but is unrelated to the Open Sets. The copper tip of the soldering iron pits excessively because the copper is lost to the tin. The erosion reaches the point where corrective action is necessary—how many soldering gun tips have you replaced? The other is the plague of instrument repairers. The extremely fine wire of meter coils and springs requires special solder because regular solder dissolves the wire before the joint can be properly completed.

Repairing faulty audio-transformer windings by the electric discharge method is often successful. The discharge re-establishes a copper-solder path across the crystallized interface. The high voltage is necessary to break down the gap and a moderate current is needed to move some metal into the new joint. Too much current results in an explosion, which leaves a bigger gap than before.

Model 10C was subject to another problem for the restorer. The damper resistors in the grid circuits of the radio frequency amplifiers often opened because the tightly wound resistance wire ruptured. To replace the resistor, the coil must be removed from the board and opened. Repairing the resistance wire is difficult. Rewinding is moderately easy if new resistance wire is available. The way most collectors go (and the purists shun) is simply to shunt the old resistor with a new quarter-watt 820-ohm resistor.

To check some of the calculations of receiver sensitivity made in reference to earlier articles in this series, No. 4052 and No. 4066, measurements were made on a Model 10C receiver that was apparently operating properly. The sensitivity was greatest in the middle of the dial, which corresponds to a resonant frequency of about 700 kHz. The zero end of the dial, about 1300 kHz, was the least sensitive, requiring about 1 millivolt to give marginal loudspeaker volume. At the other end of the dial, about 550 kHz, the set was similarly less sensitive than the middle.

The middle of the range indicated a small amount of inadvertent regeneration, the result of some feed back through the plate-grid capacity in the tubes. In Atwater Kent sets, this capacity was not balanced with neutralizing condensers. When hot, new type-201A tubes were used or with the higher-than-normal plate voltage applied to the set, oscillation could result. During the tests, the set showed that tendency around mid-dial.

The causes of low sensitivity at the high-frequency end of the dial were lowered transformer efficiency and the shunting capacity in the circuitry. At the low-frequency end, the cause was insufficient loading of the tubes by the RF transformer primaries. Single-stage measurements showed the grid-to-plate tube gain to be nearly unity. The transformer

ratio provided nearly all the stage gain. The sensitivity measurement showed that Kent's engineers achieved a good compromise among the many factors to be considered in the design of a tuned-radio-frequency receiver.

The Atwater Kent Manufacturing Company shipped Open Receiving Sets in wooden boxes. Such a box is shown in Figure 24. The history of the set originally delivered in this packing case is known, partly from the markings on the case, and partly from the original purchaser, Mrs. Hazel Rangeler of Fostoria, Ohio. The set was shipped from Philadelphia to the Toledo Ignition Co., the distributor for the part of Ohio that included Carey. There, the dealer, the A.H. Houk Hardware Store, sold the set to the Rangelers. Mr. Rangeler put hinges and a hasp on the cover to make a transport case for the set when the family went for a vacation at their summer home on Lake Erie. Through the years, the set was stored in its original box until Mrs. Rangeler made it available for the author's collection. In talking about the set and what it meant in her family, Mrs. Rangeler recalled that it was a big part of their Christmas in 1924.

As with the earlier Model 10 sets, Atwater Kent produced a Pooley cabinet version of the 10C. The receiving instruments, on their board, were enclosed in the middle compartment that was closed with the desk-front door. In the upper compartment, a horn speaker was mounted. It was driven by a reproducer similar to the one used in the Model M loud-speaker. The lower compartment was intended for batteries or the other power sources that could have been used with the set.

The part number for the set used in the Pooley Cabinet was No. 4950, even though the circuit was identical to the No. 4700. Its instruments were arranged on the board with the same spacings as on the standard 10C, but the board was finished differently. Its edges were squared and notched in the corners so as to fit into the recess in the console deck. The board carried a small identification nameplate in the front center.

The Model 10 Open Receiving Sets produced by Atwater Kent were a hardy lot. More than 100,000 sets were made. Their survival through the years and their easy restoration to operating condition is a tribute to the people who designed and made them. The quantities of each different set, produced in each year, as well as the yearly and model totals, indicate why Atwater Kent was no small manufacturer of radios. At about $100 each, the one hundred thousand Model 10 radios look like ten million dollars worth of business. When the other sets in production during those years are accounted for, and loudspeakers and other auxiliaries added, and the automobile part of the company is considered, it is easy to see that A. Atwater Kent deserved his reputation as an outstanding entrepreneur of the twenties.

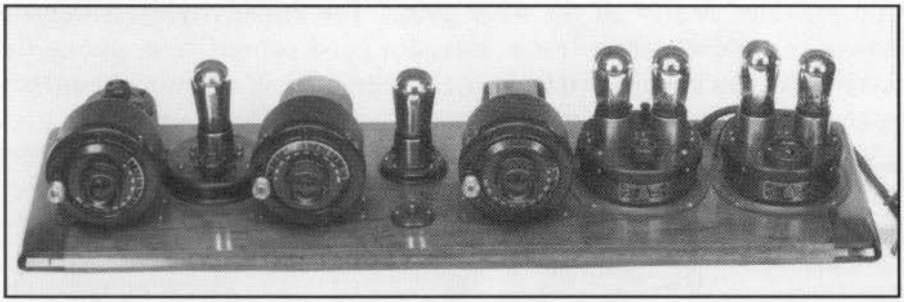


Figure 28. *Model 12. Some customers wanted the best so Kent modified the design of the Model 10, added an audio amplifier tube, and met that market.*

MODELS 12, 12B, 12C — No. 4910

Among Atwater Kent Open Sets, the Model 10 series provided the basis for portraying the development of the entire product line. Model 9 can be seen as a simplification of Model 10 and Model 12 can be thought of as the top of the line. Model 12 was clearly the "Cadillac" of the Atwater Kent breadboards. It was very similar to the Model 10 in its circuits and layout, but differed in the number of AF amplifiers. Model 10 offered two AF amplifiers following the detector; the Model 12 offered three. Figure 28 shows No. 4910, the last Model 12, referred to as Model 12C.

The difference between any Model 12 and its Model 10 counterpart was the number of AF amplifiers and how they were packaged. The means by which the extra audio amplifiers could be implemented had existed from the early days when the individual TA instruments were developed and sold, even before the production of radio sets began. No electrical designing or experimentation work was needed for Model 12. Only factory planning and assembly work was required to manufacture that radio set.

Clearly, the RF section of any Model 12 was that of the corresponding Model 10, even to the placement of the coils and the switch. The difference between the Model 12C and the Model 10C was in the use of the Detector, One Stage Amplifier and the Two Stage Amplifier instead of the TA Detector, Two Stage Amplifier that was part of the Model 10C. The factory had to finish a larger board, rework the under-board wiring, revise the test procedures and build a bigger shipping box, but that was all that was needed.

In recognizing Model 12C, No. 4910, the key points were the small tube socket for the second radio-frequency amplifier and the switch on the front of the second two-tube unit, the Two Stage Amplifier. Model

12C, No. 4910, was a brown set that corresponded to the Model 10C, No. 4700. It did not have a potentiometer, but had damper resistors inside the RF transformers that were connected between their secondaries and the corresponding grids, and used the small socket without a rheostat for the second-RF amplifier tube. The board was 10 inches deep and 34 inches long.

Model 12C, No. 4910 used two TA units: a Detector, 1 Stage, AF Amplifier, No. 4940, and a Two Stage AF Amplifier, No. 4925. These TA units were similar but not identical to the TA units originally sold as separate instruments before Kent started making complete sets. The Model 12 TA units were wired differently from the original instruments to simplify the binding post arrangement. The Two Stage AF amplifier on No. 4910 incorporated a switch to disable the last audio stage when the signal strength of an incoming station was sufficient to operate the speaker directly.

The Model 12C, No. 4910 was produced with radio transformers molded in the two styles that were characteristic of the other Open set with tunable RF amplifiers. Some sets had decorative rings, and others had the bosses originally used when the early sets had binding posts on the coils. There were some minor differences in the under-board wiring in the No. 4910 from set to set, but all were wired in the rectilinear pattern. As with the Model 10 receivers, the Model 12 sets were produced in both Atwater Kent factories, at Wissahickon Avenue and Stenton Avenue. Model 12C, the last Model 12, was probably produced only in the new factory on Wissahickon Avenue. The production rate was not high enough to justify the complexity of two assembly areas, so Model 12C was made on the lines that assembled Model 10C.

Model 12C, No. 4910 was not the first of the Model 12 radios. Before it, there had been two others: No. 4620, a brown set that corresponded to the No. 4550, Model 10B; and No. 4375, a green set, which was a Radiodyne. Quite a few No. 4620 breadboards have survived through the years, but only one No. 4375 Radiodyne 12 is known to exist today. To distinguish among the three Models the latest is called Model 12C, the middle period set is called Model 10B, and the first is called simply Model 12 Radiodyne. The letter follows the Model 10 designation.

The second version of Model 12, No. 4620 (12B) was built using the same radio frequency layout and circuits as the No. 4550, Model 10B. It had the potentiometer, the large socket for the second radio amplifier, and orthogonal radio-frequency transformers with closed ends. The set was built on a board 10 inches deep by 36 inches wide. This was two inches wider than the later Model 12C board. All the instruments were brown including the condenser cans. But unlike the later Model 12C, there was no way to cut out the last audio stage. The knob on the Two-

Stage Amplifier was a filament control connected in the same way as the one in the Detector, 1 Stage Amplifier.

The Model 12 Radiodyne, No. 4375, was built with the same RF section as the corresponding Model 10, in this case the Radiodyne, even to the nameplates on the transformers. Diagramatically, that part was identical to the Radiodyne 10, but the layout was improved a little in the direction of the later green Model 10 sets. The Radiodyne Model 12 used upright coils (not orthogonal as with the Model 12B and the Model 12C sets) and had binding posts for power instead of a cable. There were binding posts on the condensers and on the tube sockets. As with the Radiodyne 10, there were nameplates on the condensers and on the coils with the name "Radiodyne" on the left lower edge of the coil nameplates.

The TA units of the Radiodyne 12 were green, and were almost identical to the instruments sold separately in the beginning days of Atwater Kent's radio production. The difference was in the TA Detector, One-Stage, where the TIC binding posts on the Model 12 unit were used for the +A and the -A-B connections. On the original unit, the TIC connections provided access to the detector plate and its filament binding posts were up in the front of the deck panel. No example of a model corresponding to the first Model 10 (after Kent changed the nameplates) or its variations has turned up. No mention of the Model 12 Radiodyne has been found in the literature. One of these sets has survived and it is identified by its tags as No. 4375. It is not illustrated.

Each of the several Model 12 Open Sets incorporated all the improved features that Atwater Kent had developed for his radios at the time when each was introduced. Based on performance measurements made on the Model 12 series, the inclusion of the output stage-disabling switch on the Model 12C was more than a power-saving improvement. On moderate to strong signals, the use of the last stage produced so much distortion that other steps, such as reducing filament temperatures to the starvation level, had to be taken unless the last stage was bypassed. That was the means by which the Model 12B and the Radiodyne 12 were made to produce acceptable output. In their times, however, radio stations were putting out only small amounts of power so their full amplification was useful. For the listener who was especially interested in distance listening and chased the very faint signals, the Model 12 was the best choice.

Although Model 12 was the top-of-the-line radio produced by Atwater Kent, its quality was not better than the other sets; no improvement was feasible. The higher prices of the several Model 12 radios only reflected the increased AF amplification. Their appeal was to the wealthier customer in those days, and the appeal is still the same to collectors of today.

Chapter 5

REPRODUCERS AND LOUDSPEAKERS

Radio receivers of the very early twenties seldom incorporated a means of converting electrical signals into sound waves, although the mid-twenties did see some incorporation of horns in the receiver cabinets. The usual devices for the early sets were headphones, particularly since the earliest of receivers lacked the amplification to power a room-level sound reproducer.

Atwater Kent had started his radio-manufacturing business supplying instruments, but he did not initially offer either headphones for radio use or room-level reproducers (loudspeakers) in his line. It is clear though, that from the beginning, the idea of room level reproduction was part of Atwater Kent's picture of the emerging radio set market of 1922. He offered his Two-Stage AF Amplifier, No. 3634, and the Detector, 2-Stage AF Amplifier at the beginning of his production. Both of these units were clearly designed to power loudspeakers.

At about the time Atwater Kent started manufacturing receivers as complete units, rather than supplying instruments for customer or dealer assembly as he did in the beginning, he designed and produced several loudspeakers. The initial unit was Model M, Part No. 4460, and then a little later Model L, Part No. 4645. These are shown in Figure 29. The Model M speaker, about 24 inches high, used a reproducer that was very similar to the two adapter units that Kent had made for use with phonograph horns. These were 5V and 6C.

Atwater Kent produced these two units for use with phonograph horns to reproduce radio outputs. The 5V, Part No. 4437, and the 6C, Part No. 4438 were very similar. They had brown phenolic backing plates screwed into plated-steel reproducer bodies. The phono units were sold as substitutes for the needle diaphragm on a user's phonograph or, if the purchaser preferred, to be attached to a branch in a Y-shaped yoke along with the branch from the needle. The 5V was built to fit around the horn pipe, and 6C to fit inside the pipe. Electrically, the units were identical to each other and to the Model M loudspeaker.

The Model L horn was a less expensive version of the Model M. It was smaller, being only 19 inches high. Its reproducer was made an

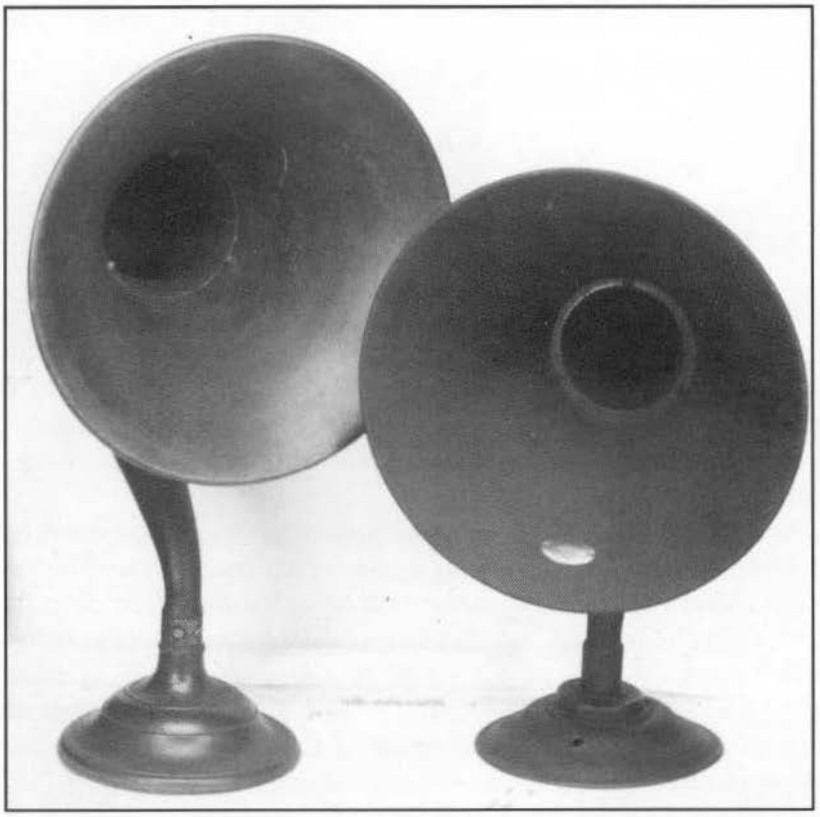


Figure 29. *Models M and L Loudspeakers. Model M was very early and still performs today. Model L and several others were offered at the time of the five-tube sets but they suffered because of their pot-metal drivers.*

integral part of the speaker, carrying the horn around its output pipe, and the base around its waist. On the Model M the reproducer was separable from the base. More important, however, and a great difficulty for collectors of today, was the substitution of pot metal in the Model L reproducer for the steel used in the Model M. The author has never seen a Model-L loud speaker that had an original reproducer that still retained its original dimensions and was adjustable. A characteristic of pot metal is to crack and swell over the years because of stress-corrosion. The inevitable result is that the backing plate freezes in the body of the sound unit.

Figure 30 shows the parts out of which the reproducer was made. The parts were those of the Type-H horn (similar to a Type-L but three inches taller). The phonograph reproducers and the Type-M unit were all similar in internal parts. The differences were in the external fastening and wire termination. The picture shows the reproducer in cross section,

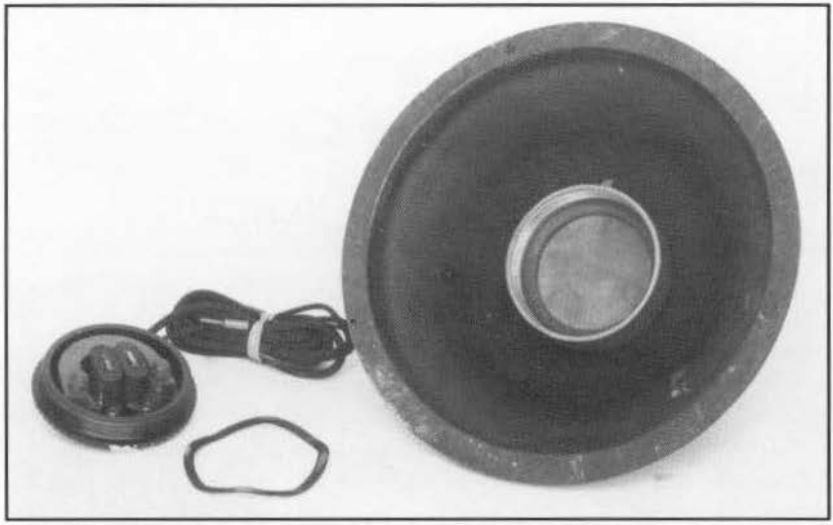


Figure 30. *Loudspeaker Driver Disassembled. Loudness adjustment was achieved by tightening the coil assembly into the base against the spring. Too far and the diaphragm bottomed on the pole-pieces.*

in a Type-H horn unit. When a collector of today obtains such a unit or a horn loudspeaker, he should first determine its condition and then work with it very carefully to avoid doing irreparable damage. If it is not a Type-M unit or a phono-adapter, the pot metal should be examined both mechanically and electrically and the coil tested electrically. Some pot-metal units still deliver sound, but usually not at their expected efficiency. It is here that the collector should stop. Getting the unit apart without destroying the bottom threaded edge of the housing (where the backing plate is screwed in) is extremely difficult. Some collectors have tried with sad results and then had to use epoxy to reassemble the units.

Not long after the Model L horn was introduced, Atwater Kent brought out several more—the G, H, and the R. They were similar in construction but differed in size and finish. The Model G was finished in two shades of green. The Model R was a smaller version of Model L. Its base was about an inch less in diameter and its bell was about three inches smaller.

Chapter 6

THE TWENTIES SERIES

MODEL 20, No. 4640

Open Sets (breadboards) established Atwater Kent as a major radio manufacturer in the early twenties. Although those receivers worked well, their appearance, as part of the living-room décor, grew less acceptable in the American home after the novelty of having a radio wore off. The Open Sets were beautiful in a functional way but were ugly to the housewives who had to dust them and to keep people from touching their innards. Atwater Kent, being sensitive to his market, quickly recognized his customer's need for an enclosure. It was his nature to meet this need by designing and building enclosures that pleased him. His taste was for simple lines and functional controls; the Bakelite or hard-rubber panels and wooden-shelf construction common to other suppliers was unacceptable.

With his strong mechanical background, Atwater Kent was ever alert for ways to improve his products through the use of new materials, or by using standard materials in new ways. His exposure to the automobile industry, occasioned by his successful line of electrical products, including ignition systems, starters, and generators, and his continuing friendships with people in that business, led Kent to apply their experience and methods to his radio manufacturing. Two major developments in automotive manufacturing in the mid-20s were potentially valuable, machine assembly and steel shaping. Of the two, steel shaping, the means by which the major structural member of the radio was formed from sheet metal, was the more important.

Kent's view of manufacturing economics pointed to use of metal for the main structure of the radio. But the drawn and punched-metal chassis was still in the future. His practical step in that direction was to use metal for the panel with a welded shelf to carry the tubes and electrical parts. The big Twenty, No. 4640, Figure 31, put into production in 1924, was the radio that embodied all these ideas. Its enclosure was a mahogany box with simple lines and a deep brown, piano finish. The working circuitry was assembled on a single shelf welded to the metal panel. The tube sockets were attached to the top of the shelf and the wiring ran along the under-side. The idea of using a three-tube detector-audio-amplifier unit

was retained by mounting all three tubes on a Bakelite deck of rectangular instead of round shape. The cylindrical TA can of the Model 10 was dropped and the audio transformers were individually enclosed in flanged-steel cans which were, in turn, mounted on the tube deck with the detector and AF amplifiers.

COMPARISON TO MODEL 10

Because the Model 20 is a part of so many collections, a detailed description of its appearance is unnecessary in this review. However, some of its less well known characteristics may be of interest. One surprising aspect is revealed by a comparison of the Model 20, No. 4640, to the last of the Model 10 line, No. 4700, sometimes called the "Model 10 Compact." Electrically, they were identical, even to the same circuit diagram and the same power and signal requirements. Mechanically, they appeared to be quite different, but the arrangement of the tuning dials was identical, and the spacing between them and between the RF transformers was nearly the same in both sets. The RF transformers of No. 4640 were mechanically smaller (two inches in diameter instead of three) and their alignment was different, but they were identical in their electrical performance.

The transition from the Model 10 series to the Model 20 was mostly mechanical. No large electrical problems were encountered at the time of production and no particular difficulties are experienced today in getting repaired sets to work. The main problem in repairing both Model 10s and Model 20s is the loss of continuity in the AF-transformer windings.

Many of the parts in the Model 20 were virtually identical to those in the Model 10. Examples are the variable condensers, which were structurally attached to the faceplates of the cans in the Model 10 but were mounted on the panel of the Model 20 using a simplified front insulator plate. Because the cans were not used, the condensers looked very different, but the shafts, plates, spacers, screws, springs, and bearings were identical. The tube pin springs, screws, acorn nuts and brass UV shells used to retain the tubes were all identical in both radios. The AF transformers were internally identical, differing only in their external casings. As with the Model 10, damper resistors were used to lessen the effects of capacitive coupling through the tubes.

Another similarity between the Model 10, No. 4700 and the Model 20, No. 4640 was the spacing between tuning condenser centers. The spacing on the last version of the No. 4700, Model 10, The Compact, was about 6 3/4 inches. The condensers on the regular No. 4700 were spaced about eight inches. In designing the Model 20, the condenser

spacing was maintained at a little over six inches. The biggest advantage gained from retaining the spacing was to avoid a change in the inductive coupling characteristics of the RF stages and thereby to minimize design problems from unwanted feedback.

The antenna coil also retained the tapped primary, introduced on the Model 10B, to compensate for antennas of different lengths. The switch was moved from the top of the coil form to the front panel but the circuit was not changed. The other differences in the RF design of the main production runs were: going from cast coil forms to fiber cylinders cut from a large piece of tubing, and mechanical brackets used for fastening the coils to the rear plates of the condensers.

FACTORY STARTUP OF THE MODEL 20

Work on the design of the Model 20 must have started at about the time that the first Model 10, No. 4340, was current. The basis for this statement is that the big twenty and the first Model 10 were equipped with binding posts for connecting the power sources, but all subsequent Model 10s had power cords. This idea conflicts with the thought that the RF-tuner design appears to derive from the last Model 10. A possible explanation may lie in the very short production times of the Model 10A and B sets. Kent's wooden-box sets may very well have been conceived and experimented with while the No. 4340 sets were current.

If the design of the Model 20 had been started at the time of the cordless Model 10, No. 4340, and if the steel panel made the design of the tuned stages difficult, work on the small coils would have been going on in the laboratory when orthogonal coils were introduced in the later Model 10s, such as the 10B and 10C. Work on their transformers would have displaced the design of the smaller coils and delayed their introduction still more. Getting uniform stage gains over the broadcast band while maintaining selectivity and avoiding regeneration had always been a difficult, cut-and-try process, which was grossly affected by removing the condenser cans and mounting the condensers on the steel panel.

There may have been another requirement for those coils: uniformity. The inductances and the stray capacitance had to be uniform enough to permit tracking with coils that were half the size of the coils on Model 10. While this was premature for the Model 10 sets and for the big Model 20, it must have been in the marketing wish list. They had to respond to Mr. Kent's continuing interest in a more compact radio and the customer's interest in getting away from the frustrating three dials.

The laboratory people assigned to this design task must have been under great pressure, since the general mechanical design, production

planning and material ordering went on in the ordinary course of affairs. However, the RF design was finally accomplished and it was very successful, since it survived all the way into the Model 30.

THE TRANSITION TWENTY

Before the main production of Model 20, No. 4640 started, Kent made a few transition sets. They were characterized by having coils of the same dimensions as those on the Model 10, No. 4700. The intriguing point about this similarity is that a prototype Model 20 was made and sold before the familiar version was in full production. The RF transformers on the prototype were the same diameter as those of the Model 10 (three inches), and they were aligned identically. A close examination of the transformers and the mounting brackets reveals scribe marks, suggesting that the tuners were made in the model shop. The new, smaller transformers which were required were difficult to design and produce with the same inductances, turns ratio, losses and strays as those in the Model 10 and, initially, were not precise enough for tracking. The time that had been allocated to meet the production and marketing deadlines (and possibly Mr. Kent's patience) became short, so the larger coils were used temporarily.

Another peculiarity of the prototype 20 was the nameplate. It was the one used on the No. 4330 Five-Tube Amplifier produced for the Model 5. Again, this might have been the result of a production delay in the etching shop, but a more likely explanation is that the non-standard nameplate was the company internal identification of the prototype 20, which was instantly recognized by the dealers but would not have offended the customers. It could be argued that a nameplate with a different marker color or a different serial-number sequence could have provided the separate identification. But then what would have been done with those old Model Five nameplates? Only five or six of those sets have survived. They can be identified easily by their nameplates.

In comparing the Model 20 receiver to the last of the Model 10 series, many details were discussed. They provide the basis for another conjecture. It is this: The Model 20 was designed at the same time as, or a little before, the Model 10C (instead of subsequently as most collectors assume). To support the conjecture, the foregoing comparisons may be re-considered as two parallel extensions of the Model 10B, No. 4550 & No. 4560 sets. Consider the production dates: No. 4550, December, 1923; No. 4560, January, 1924; No. 4700, May, 1924; and significantly, No. 4640 (the Model 20) April, 1924. The design groups must have been working on No. 4700 and No. 4640 late in 1923 so that the factory could start ordering parts and materials in early 1924. Assembly areas had to be rearranged

for the Model 20, assemblers taught the new processes, and stockrooms replenished to accommodate the closed sets. Even with the efficiency of the Atwater Kent factory, several months must have been required for the expansion.

All this was being done while the 4500 series was in production, the early production of the 4600 series was initiated, and the changes for the 4700 series were being introduced. The task was large but not much different from the other changeovers that had taken place in the factory. Production of the metal panel for Model 20 with its L-shaped, spot-welded sub-panel is an example, It was a milestone in the manufacture of radios in the three-dialer days. Few other manufacturers used steel as the main body of their radios. Stewart Warner, Grimes, and Cleartone employed steel panels but used brackets to attach a phenolic sub-panel, which in turn carried the tube sockets. The Atwater Kent steel panel assembly, later to become known as a "chassis," enabled progressive assembly along a line by operators at fixed work stations. As the increasingly complete assembly was carried past each station, the operator would install his particular sub-element on the main panel.

It is easy to visualize the assembly line. At one end, the painted panel started its journey. Perhaps the first steps were the installations of the filament-rheostat unit and the antenna switch. Then, because of the closeness of the major subassemblies, the by-pass condenser was installed, followed by the radio-amplifier tube sockets. The tuning condensers, with their coils attached, were installed in the next work stations. The last unit to go on was probably the Bakelite detector, two-stage audio-amplifier sub-unit. Part of the wiring was attached to each unit before it reached the production line. Some of the wiring could then be finished at stations adjacent to the mechanical-installation stations. The remainder, those long wires that were run along the under side of the L-shaped shelf, were the last pieces to be installed on the nearly complete panel. After that, the finished unit went to the electrical test.

Doubtless making the cabinets in which the Model 20 was enclosed was the biggest activity. Compared to the Open Set boards, the work of making, assembling and finishing the mahogany boxes was increased greatly. The impact in the wood shop must have been strong since no reduction in Open Set production took place. Instead, the overall production continued to rise, with the closed sets simply adding to the work and to the reputation of Atwater Kent.

MODEL 20 PANEL SET, No. 4670

The big Model 20, No 4640 with its crinkle-painted, brown-steel panel enclosed in a dark-brown mahogany cabinet, is generally regarded



Figure 31. *Model 20. When styles changed, and the Open Set was passé, Kent simply mounted the parts on a metal chassis and enclosed them in a mahogany box.*

as the best example of an early Atwater Kent table-model receiver. Although that version of the Model 20 was the predominant receiver made in the brand new Wissahickon Avenue factory during 1925, several variations were also produced. One was the fully assembled and tested steel Panel Set, not installed in a cabinet but packed directly in its shipping carton, and identified as the "Model 20 Panel", Part No. 4670. This variant illustrates another interesting facet of the operation of the company; *viz.*, a response to a market demand for console radios instead of table models. Even Atwater Kent felt the demand to be less than he would tool up for.

Kent was a strong entrepreneur. This quality extended over the many business areas of his life, some of which have been identified earlier. The cabinet used for the big Model 20 exemplifies an area where his strong views became the direction his company took. He liked plain, solid wood construction, particularly in household items that had to embody both utility and beauty. He was equally emphatic on finishes, having a marked preference for carefully filled, hand-rubbed mahogany. More important, he felt that a radio had to relate its function and its form. All of these preferences led to acceptance of the plain table-model set and the rejection of a floor console.

During the production of the early Model 10s, some boards were made available to other companies who marketed them independently. Customer acceptance was moderate at best, with the result that Atwater Kent's preference to stay out of the furniture business was reinforced. A good compromise among these views, while still making it possible to sample the potential market, was to make the Model 20 Panel available to other commercial firms for assembly into consoles or other pieces of

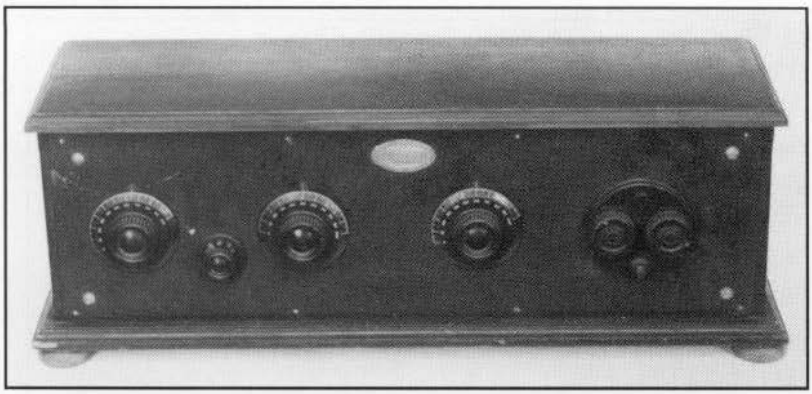


Figure 32. *Model 24. Some homemakers, but not the majority, preferred the shelf style to the rounded box. Only Model 24 was offered in that style, and it was not popular enough to be used again.*

furniture, with sales through their own marketing channels. An example was the Pooley Company, a major furniture manufacturer in Philadelphia.

Pooley had used the 10B and the 10C in large consoles that included a loudspeaker and accommodations for batteries. Only minor changes were needed to created a new console radio that was based on the Model 20 Panel. Some present-day collectors question whether the Pooley Co. and Atwater Kent were independent, since much of Pooley's advertising heavily emphasized the Atwater Kent name. The policy statement from one of Pooley's brochures clarifies this point: *"The policy of the Pooley Co. is to specialize in a line of work in which they have no peer—fine cabinet making—and they leave to trained Radio Engineers the designing and manufacture of the Radio Equipment which is built into Pooley Radio Cabinets."*

THE DELUXE, No. 4920

Another variation of the big Model 20 was called the "Deluxe" and sometimes given the designation "Model 24," Figure 32. Because it was based on a standard Model 20, No. 4640, it was also referred to as a "Model 20D." At first glance, the panel of Model 20, No. 4640 and the panel of Model 20D appear identical, but closer examination reveals that the medallion and the milled-edge escutcheon buttons were finished differently on the two sets. On the DeLuxe the medallion and the dress pins at the corners of the panel were gold-plated as was the pull switch, but on the regular Model 20 and the Model 19, the medallion was bronze and the pins were silver (nickel). The other difference (beside the cabinet)

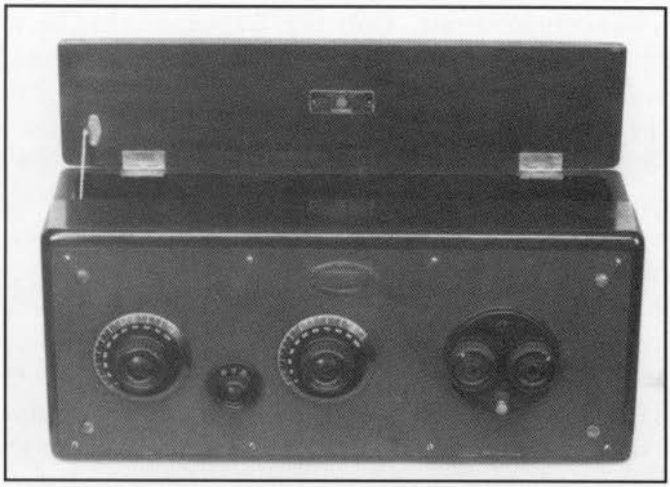


Figure 33. *Model 19. In the same way that Model 10 was supplemented by Model 9, Model 20 was accompanied by Model 19.*

might have been in the serial-number range. The nameplates of the DeLuxe were identical to the big 20 but the serial numbers must have been different so that the sets could be readily identified in the factory records. The Deluxe probably had serial numbers assigned in narrow segments of those consigned to all Model 20s. Since the author has No. 8344 and Bob Robbins has No. 64,813, perhaps the segment from 5,000 to 10,000 was used in 1924, and 60,000 to 70,000 used in 1925.

For factory records and for billing, Model 24 (20D) had to have a separate part number, so it was identified as No. 4920. The cabinet of the Model 24 was more ornate, having a molded-edge top cover and a matching molded base. It was the first of the Atwater Kent receivers to have feet instead of felt scratch pads. The popularity of the style seems doubtful, since the number of Model 24s produced was less than one-twentieth of the quantity of big Model 20s, and since the molded edges were not repeated in other sets that were enclosed in wooden boxes or metal cabinets. In the tabulation of sales by year for Atwater Kent sets, and in advertisements of that time, No. 4920 was called Model 24 and was sold in 1924, 1925, and 1926. The total number of sets sold was 8,966. The author conjectures that this version was an effort to sample the market; the result was a justification of Mr. Kent's views on styling.

MODEL 19, No. 4880

In 1924 the number of stations that had to be sorted out by tuning did not make selectivity a difficult problem for rural and small-city listeners. In a big city, there were more and stronger stations but even in Philadelphia,

the problem was only moderate. Only four frequencies had been assigned, and these were well separated. They were 1050, 833, 760 and 590 kHz. Model 19, No. 4880, Figure 33, with only one RF amplifier could separate these stations with little or no trouble except for the listener who lived in the immediate neighborhood of a transmitter. The demand for selectivity became important for him and for everybody else on winter nights when propagation conditions brought in distant stations on close channels. Under those circumstances, Model 19 showed its limitations.

Some localities in the United States were more favorable than others for radio reception. For the DX fan, a quiet location away from a population center was a must (except for those nights when crystal sets turned into DX wonders). The average listener, however, had by this time become more interested in program content and was not inclined to spend large amounts of time and money trying to capture strange or distant stations. A location near a city where the signals from several favorite stations were strong and where selectivity was not a controlling requirement meant that a radio with less capability than a standard three-dialer might be adequate. A receiver having only one stage of RF and a tuned detector could provide satisfactory performance and at the same time save the listener some money. Sales of the Model 9 had made this point clear to some people at the Kent factory.

But one wonders what factors the buying public of the time considered to be the important elements of a radio purchase. With five-tube sets such as the Model 20 so common in today's collections, and four-tube tuned-radio-frequency sets, like Model 19, so relatively scarce, price appears to be doubtful. The Model 20 sold for $80 (less tubes, power supply and loudspeaker). The Model 24 sold for $100. A commensurate price for the Model 19 was $65. Was this $15 to $35 reduction enough to attract buyers whose radio reception did not require the added sensitivity or selectivity of the second RF amplifier? Because Model 19 was not a best-seller there must have been other negative reasons. Perhaps one was limited advertising and inadequate product acquaintance. Another might have been a customer's feeling of not just wanting good-enough, but selecting the best. Kent's customers were economically in the high-middle class and may well have rejected the bottom-of-the-line.

Model 19, No. 4880, was made up of a simple tuned-RF amplifier, a detector, and a two-stage AF amplifier. It bore the same relation to Model 20, No. 4640, as Model 9C, No. 4660, did to Model 10C, No. 4700. The styling and design of Model 19 were based on the big Model 20, both mechanically and electrically, and like the big Model 20, it used the welded panel and shelf for strength and electrical assembly. It was not equipped with a power cable, but instead retained the binding

posts of the big Model 20. The circuit was identical to Model 9C (less cable) and the same as Model 20 less an amplifier stage. It was derived from the Model 10 series except for the second RF amplifier. Like the Model 20 and the Model 10C, No. 4700, there was no potentiometer used on Model 19.

The RF transformer coil with the vertical axis used in the Model 20 did not appear in the Model 19. Instead, the set was shorter by the distance between condenser shaft centers: six inches. The over-all width of the Model 20 was 25¾ inches. The corresponding dimension of the Model 19 was 19¾ inches. The other dimensions of both sets were identical: eight inches high by eight inches deep. Comparative examination of both sets indicates the only other differences were in the medallion placement and locations of the fastening screws on the panel. On each set, the medallion was centered on the longest dimension and eight screws, evenly distributed across top and bottom, were used to secure the panel to the cabinet.

The sensitivity of the Model 19 for a quiet-to-moderate loudspeaker output was measured to be about one-half a millivolt. This corresponds to an overall amplification of a little less than 20,000, a value entirely appropriate to the four tubes and proportionate to the amplification of five-tube sets. The user of a Model 19 would have been served well if he were in a small city that had three or four stations well spread on the dial. These would have provided sufficient variety to make distance chasing the exception rather than the rule.

INTRODUCTION OF THE MODEL 19

The timing of the introduction, three months after the big Model 20, indicates that there was no earlier prototype version, a tribute to the RF coil and tuner design, since the coupling between the antenna and detector coils was increased by removing the intervening stage. Because the Model 19 bears the same relation to the big Model 20 that the Model 9C does to Model 10C, Kent appeared to have expected some market for an "economy" set. Model 19, Part No. 4880, was manufactured in 1924 and 1925, but its production was limited, amounting to less than 6000 sets. Apparently, the market was not only small but fleeting, since no later single-RF-stage receiver was ever offered.

Early 1924 must have been an interesting time at the Atwater Kent factory in Philadelphia. The last Model 10C, No. 4700, and the first Model 20, No. 4640, were being introduced into the production process that was still occupied with orders for earlier sets. First production for the big 20 was in April, and in May, the No. 4700, Model 10C, made its debut. At the same time, the Model 9C, No. 4660, was introduced, but

because of its similarity to Model 10C, its impact was not as heavy. After May the highest level of pressure was off, but things must have seemed better only by comparison, since the cabinet Model 10B, the later Model 12, the Model 19, the Model 20 Deluxe, and the Model 22 were still in the works, to be introduced by the end of July.

A still bigger factor in the chaos of implementing the new factory on Wissahickon Avenue was the extent of the new space. Kent was no longer limited for manufacturing space as he had been at Stenton Avenue. He had fifteen acres in the new plant alone. His effort had to go into bringing the new facility up to efficient operation. Production efficiency in any factory rises when the process is stable. The delays caused by material that is not at the right place at the right time must be removed by improved order and delivery practices. Operators must have time to learn their tasks and consequently drop the number of their errors to nearly zero. Only then can the actual produced cost approach the planned cost and profitable operation be expected. In early 1924, the conditions at the Atwater Kent factories were nearly opposite to those necessary for efficiency. New sets were being introduced monthly or even more often. During the entire year, 27 variations of seven different models were produced. At the same time, the number of sets produced per unit period of time was rising sharply.

And at about the same time another change took place in the factory. The entire approach to assembly was revised. The process for early sets was largely unit assembly; a single craftsman fastened the instruments on the board using wood screws, and the same, or another, craftsman did the wiring using staples to secure the conductors. The work was similar to that done in a cabinet shop. Nearly no soldering of wires to instruments was required.

Cabinet sets such as Model 19 and Model 20 changed that system to a production line where an operator could repetitively perform a single, simple, assembly operation as the sets passed his work station. For example, the tuning condensers could be mounted on the panel by a different operator from the one who mounted the radio-amplifier tube sockets. This division of work was recognized by Atwater Kent as vital in raising his factory's production efficiency.

The factory floor must have been, to an outsider, a beehive of activity. Benches, parts bins, and assembly stations must have moved like checkers as different sets were established with separate lines. But not every set needed a separate line; the Model 19 and the Model 24 were nearly identical to the Model 20 and could well have been produced on its line. Therefore, on the several lines, the exact details of the assembly, and the parts necessary, must have been changing, too. Unless that factory was different from all others, production foremen, engineers, and technicians

must have been all over the place. Above all the activity, we may be sure, was Mr. Kent deciding, directing, and demonstrating. This author would surely like to have been there.

To get a feel for the activity, consider the growth plot in Figure 34. At the beginning of the year, about 2500 sets per month were being built. By the end of the year the number had increased tenfold. Even more interesting is the abrupt rise in April or May which was the result of going to the Model 20 cabinet receiver.

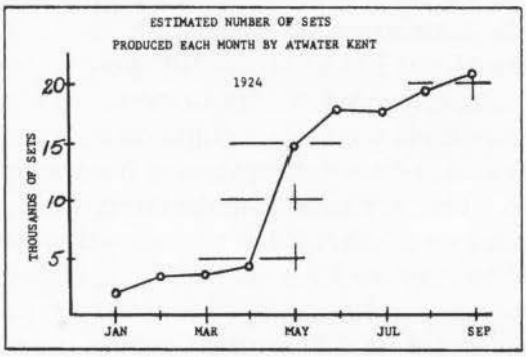


Figure 34. *Growth Plot, 1924. The new plant at Wissahickon Avenue was certainly a good investment. Stenton Avenue was hardly large enough to make 1000 sets per month.*

MODEL 20C, No. 7570 and No. 7960
MODEL 21, No. 7780

As the year 1924 went along in the Atwater Kent factory, radios were being turned out at a prodigious rate. In the second half of the year, the production must have reached 20 to 25 thousand sets per month, more than 1000 sets per day. The Model 20, No. 4640, accounted for about three-quarters of the production, with the Model 10C, and special variations for consoles, making up the fourth quarter. Doubtless, the rates continued to climb as 1925 brought more and larger markets to the radio business.

What were times like in this new world of radio? Listening-in had changed from a curiosity to a part of family life for millions of families. Announcers like Graham MacNamee were well-known personalities. Music of all kinds had become a staple for broadcasters. The era of radio stars had been born, and the popularity of a radio personality demanded him for public appearances in addition to his air time. Radio had begun to rival the movies as a form of entertainment.

The difficulties of sharing time on a particular wavelength had abated, to be replaced by the problems of receiver tuning. Acquainting a radio

listener with the art of tuning his receiver to bring in the desired station was more of a chore than simply publishing the station wavelengths. None of the dials were calibrated in wavelength, the standard means of referring to the place in the spectrum where the station was to be found. General use of "frequency" instead of "wavelength" had started, but had not become popular. Dials were marked with arbitrary divisions, usually covering one-half the periphery with 100 divisions. Atwater Kent dials on earlier sets had increasing numbers arranged counter-clockwise. Increasing numbers on those dials were in the direction of increasing wavelengths but did not correspond numerically.

The dials on the Model 20 and Model 10C were arranged oppositely so that increasing numbers tended to relate to increasing frequency. While the change may have made the tuning a little easier, the requirement to adjust two or three station dials still kept tuning from being as convenient as it later became. The way most manufacturers worked the problem was to provide a card on which the dial settings were recorded, initially by the dealer, and later by the listener.

One very important, and popular, radio offering was the political speech. Toward the end of 1924, President Coolidge, running for election (he had become President at Harding's death), used the radio to its fullest extent. He was well suited to the radio whereas other politicians were better skilled in personal appearances. Coolidge's strong victory was attributed to the effectiveness of radio in his campaign. Reporting the election returns was one of the outstanding events of 1924, in part because of the size of the radio audience.

NETWORKS

In the eventful years of the Model 20, two ideas very familiar to later generations experienced the pangs of infancy and the trials of growing up. These were interconnecting radio stations into networks, and paying for programs. Networks had been conceived earlier but technical difficulties made them unattainable for any but the very few early experimenters such as electrical companies and newspapers. The American Telephone and Telegraph Co. (AT&T) connected their pioneering station, WEAF, with others by means of special telephone circuits to form the first network for experimental use. By the time of the Coolidge Inaugural in March of 1925, AT&T had achieved a national network of twenty-one stations covering the country from coast to coast and reaching an audience of perhaps 15 million. No wonder Atwater Kent was busy building sets when the whetted appetite of the nation provided such a market.

The second problem of broadcasting was as fundamental as the nature of broadcasting itself. Who would pay for the artists, the price of production,

and the cost of airing all the different programs demanded by this vast, unseen but strongly felt audience? Many suggestions were made and numerous ways tried. One of the earliest was the use of a station to convey its owner's message. While this worked for such owners as department stores and newspapers (and, of course, RCA, GE, and Westinghouse) the costs of production and operation soon brought many little stations (250 watts or less) to the point where they simply could not stay in operation. During 1923 and through 1924, more stations released their right to broadcast than were newly licensed. The total number of active stations actually decreased although it was generally felt in the winter of 1925 that the 86 available channels were overcrowded by the 563 stations holding licenses.

AT&T had its own answer to the cost of broadcasting: offering broadcast time to companies that had products or services to advertise to the radio audience. Station WEAF, the AT&T station, produced programs and sold time for other advertisers, showing other owners how they might operate profitably. This was not at all altruistic since AT&T sold transmitters and licensed (for a fee) other stations to rent time. AT&T felt that they had patented the right to make a radio-broadcast station available for hire. Subsequently, AT&T retreated from this position, but the way to pay for broadcasting had been established.

One of the customers for services of WEAF was Atwater Kent. It appears that on January 22, 1925, the Atwater Kent Radio Hour was originated on WEAF. The following week "The Atwater Kent Radio Artists" were on the air with a regular program from 9 to 10 p.m. Accompanying the production of quality radios, such as Model 20, Atwater Kent availed his company of the opportunity to advertise directly to the market while at the same time avoiding the problems and risks associated with operating a radio station.

THE COMPACT SETS

The factory was busy with production, the engineering group was busy with new sets and Mr. Kent had no time to become a radio station owner. He had not given up his idea that smaller was better. His continuing intention was to make a compact radio. It would displace the big sets that were typical of beginning radio. By this time there was quite a history of his efforts. The set identified as Part No. 4066 became Part No. 4333, Model 5 by enclosing all the circuit elements except the tuner in the five-tube unit. The Model 10 series became smaller partly by improved circuitry, and partly by simple space reduction. The use of the welded-steel panel on the Model 20 brought about further size reduction, this time in depth instead of width.

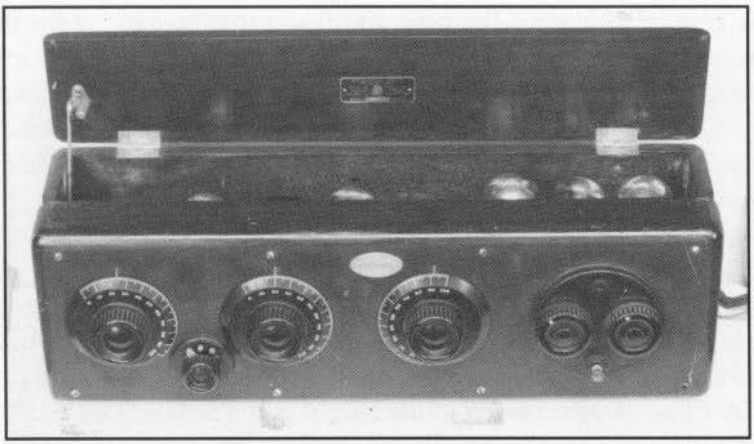


Figure 35. *Model 20, compact. The only conceptual change that took place for this set was in removing the unused volume from the big Twenty. The engineering took somewhat more effort.*

Although the big Model 20 continued the potential for size reduction through more efficient mechanical design, the true benefit of size reduction was revealed in the compact Model 20C. It used all the parts from the larger set, but enclosed them in a little less than one-half the volume. This time the basic design was sound and the conversion would succeed if the market liked the result.

In March, 1925, the new product was put into production. It was the Model 20 Compact, No. 7570, shown in Figure 35. Its cabinet had been reduced in width (from the big Model 20) by six inches. The other dimensions had been reduced to make a cabinet of 20-inch width by 6½-inch height by 6½-inch depth. As was the method of Atwater Kent engineering, the instruments were either identical to their predecessors, in this case the big Model 20, or were direct reductions based on the new cabinet size.

The design of the steel panel with its welded shelf to carry the instruments, tube sockets and AF-transformer mounting panel that Atwater Kent used on the big Model 20 was again used with the Compact 20. While the proportions were altered, the layout was the same so the electrical problems were minimal. Coils, condensers, and circuit values on the No. 7570 were carried over directly form Model 20, No. 4640. The spring contacts in the tube sockets were changed to replace the earlier double spring contacts with single-layer springs riveted to the phenolic casting. On the No. 7570 the UV type brass-bayonet cylinders were retained. The socket phenolic was made a little smaller, particularly in the three-tube detector and the AF-amplifier unit to reduce the depth of the chassis.

Several other changes were made in designing the Compact 20. The binding posts for power were replaced by a cable soldered in place, but more important, the operating conditions of the power-output stage were improved. The type-201A tube had been designed to operate at plate potentials up to 135 volts, even though the earlier sets had used only 67 to 90 volts. For a given signal input at the grid of the last stage, increasing the supply voltage increased the output, but it also increased the plate current excessively.

Since battery energy was the main cost of operating a radio in the mid-1920s, a greatly increased plate current was not popular. The design method for reducing plate current was to increase the grid bias by applying the proper amount of negative voltage on the grid. At the same time, the bias reduced the output distortion by operating the tube in its linear region. Bias was applied to the last AF amplifier stage bringing out a separate lead from the secondary of its transformer to a tap on a "C" battery. On the Model 20C, No. 7570, both audio stages used the high voltage (90-135 volts), so the grid returns for both audio stages were brought out and connected to the bias voltage for better operation of the AF amplifiers. The RF amplifiers used an intermediate value of 67½ volts, and the detector used 22½ volts.

Vacuum tubes for home use in the early 1920s were held in their sockets by a side pin that engaged an L-shaped slot in the restraining cylinder (bayonet brasses). Such a socket was substantially more expensive to manufacture than one that gripped the tube pins with spring clips. Therefore, set makers prevailed on the tube manufacturers to increase the length of the connection pins enough to give room for pin grippers. The desired improvement was identified by the change from the UV to the UX bases in mid-to-late 1925. Model 20C, Part No. 7570, like all the previous Atwater Kent radios, was built with bayonet-type tube sockets.

However, Part No. 7960, the later Compact 20, used shaped-spring contacts to grip the sides of the pins, thereby making electrical contact while also mechanically restraining the tubes. The change was not reversible; the newer tubes could be used in both the old and the new sets, but the old tubes could be used only in the old sets. Such a limitation was unimportant to radio purchasers of the time; it only plagues collectors who have limited supplies of 201As for restoration work.

Several other improvements were made in the design of No. 7960: The first AF transformer was replaced by a new high-ratio AF transformer; the AF-amplifier plate and bias voltages were rearranged; and the detector bias was altered. A fixed, filament-dropping resistor was used for the AF-amplifier tubes with the second rheostat controlling only the detector. The grid leak was returned to a tap on the bridging filament resistor.

The plate of the first AF amplifier was no longer connected to the high voltage but to an intermediate voltage of 67½ volts.

These changes all served to maintain or improve performance while reducing the battery drain. Other differences between the two 20 compacts were minor. One was in the color of one of the wires in the power cable; a blue C- wire on the No. 7560 was changed to green with a yellow tracer on No. 7960. Another was that the gold medallion on the front panel of the early set was changed to bronze on the later receiver.

The Model 20 Compact was a very popular receiver. Altogether, nearly one quarter million were made. They were started in 1925 while the big Model 20 was at the top of its production and continued into 1927. Production of the first Compact 20, Part No. 7570, totaled more than 163,000, all in 1925. The main portion of the second production run of the Compact 20 took place in 1926, during which a few more than 76,000 of the new Part No. 7960 were assembled. The remainder, about 6,000 sets, was made in early 1927.

During the early-to-mid 1920s the type-201A vacuum tube was proved to be a reasonably reliable amplifier. However, it still had one drawback; the rechargeable battery required to heat the filament. During the same period, another tube had been developed to ease the problem. It was the type-UVI99, powered by a series of three 1½-volt dry batteries such as the No. 6 cell. While this tube required only 1/4 the amount of filament current as the 201A, it is doubtful if the cost of operation was lower, since dry battery costs were high, but they were much less messy to use. Also, without the necessity of the frequent recharging required by the wet-cell batteries used with the UV201A tubes, radios with the UV 199s were more convenient to maintain in the home.

To take advantage of this tube, in the summer of 1925 Atwater Kent introduced another receiver based on the Model 20 Compact; Model 21, Part No. 7780. It was nearly identical to No. 7570, with the main difference being the tube sockets, which were the smaller bayonets required for the smaller tubes and the filament rheostats. The resistance of the filament rheostats was increased to enable the reduction of the 4.5 volts from new batteries to 3.3 volts, the limit for filament voltage if the risk of emitting-surface-deactivation was to be avoided. The underside wiring was modified to accommodate the diagonal filament connections of the type-UV99 tubes.

Starting about mid-June of 1925, Atwater Kent manufactured Model 21 sets. One would have expected the use of the dry-cell tube to have a strong appeal to radio listeners who disliked the use of the wet-cell "A" battery but that did not happen. Model 21 did not appeal to customers since its total production as given by the factory figures was only 17,584

during 1925. The figures for 1926 show no production. An unexpected catastrophe turns up in the 1926 production figures which show the 20C, No. 7960, continuing the successful pattern, but the return to the factory of 7,208 Model 21 sets.

The type-UV 99 tubes must have been very difficult to use. If the experience of early users of the type-UV 99 tubes was like the experiences of today's collectors, there can be no doubt that the set was unreliable. The low filament power was just not enough of an advantage to make them competitive with the Model 20C using type-201A tubes, especially when they tended to lose emission and burn out because of excess filament voltage.

These production numbers indicate that only about 10,000 Model 21 receivers were put into household service, a very poor showing compared to the various Model 20s. Since no other radio using either type-UV199 or type-UX199 tubes was made by Atwater Kent, one is led to conclude that only RCA was willing to utilize that tube, even with its advantage in reduced filament energy.

Because Model 21 sets are not common in collections today, as compared to Model 20C, the suggestion has been made that the factory rebuilt them into No. 7570 by changing the sockets. Atwater Kent would not have tolerated representing such rebuilt sets as new. Rebuilding might have been done with the strict proviso that the rebuilt sets were to be sold only to employees.

Chapter 7

THE THIRTIES SERIES

MODEL 30 — MODEL 30A — MODEL 48

The convenience of receiver operation up to 1926 was severely limited by the need to individually adjust the several tuning circuits in the receiver. The problem was even worse when the dial settings were greatly different; a condition typical of antennas tightly coupled to the first tuned-radio-amplifier stage. Ganging of the radio-frequency tuning dials was the solution, but two technical improvements had to be put in place before ganging could become practical for the general radio public. Antenna-capacity effects had to be isolated from the tuning circuits and the circuits themselves, including the amplifier tubes, had to be much more precise than for individual circuit tuning.

The most difficult condition occurred at the high-frequency end of the broadcast band, where the unmeshed tuning condenser contributed only a small part of the total resonating capacity. Large variations in the small total capacity, caused by variations in the circuit elements, detuned one or more stages in a ganged system and therefor desensitized the overall radio circuit beyond acceptable limits. Condensers could be made very precisely so that factor was relatively easy to control. But another part of the problem was in manufacturing uniform interstage transformers. While this was more difficult than making condensers that were exact duplicates, it was accomplished with accurate coil-form production and careful operation of the coil-winding machinery.

By using the same kind of precision for the design and the wiring of the receiver itself, the set manufacturer could control the stray circuit capacity. The problem that still remained was the variability of the inter-electrode capacity in the vacuum tubes used as the RF amplifiers. However, by 1925 the amount of parameter-variation in the tubes sold by the Radio Corporation had been reduced to small fractions of the specified values. Capacity changes from tube to tube were so small that interchanging them between stages or replacing them for reasons of wearout did not objectionably reduce the performance of the RF amplifiers in a gang-tuned radio.

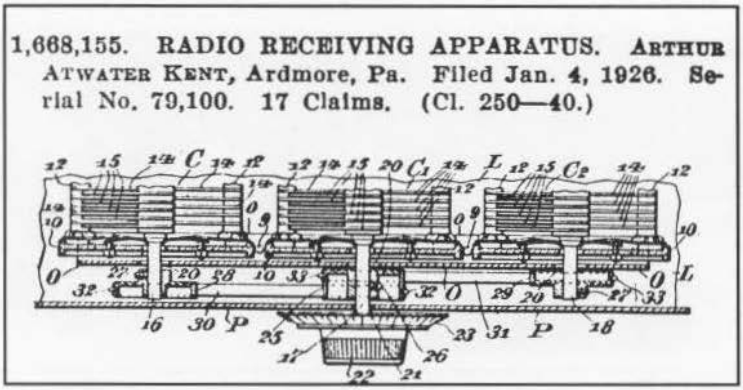

1,668,155. RADIO RECEIVING APPARATUS. ARTHUR ATWATER KENT, Ardmore, Pa. Filed Jan. 4, 1926. Serial No. 79,100. 17 Claims. (Cl. 250—40.)

Figure 36. *Kent Ganging Patent. The drawing shows the early Model 30 but the patent covered all variations that had pulleys and belts.*

Many ways to provide mechanical ganging have been devised. Perhaps the best was the mounting of all tuning capacitors on a single rotatable shaft. John V.L. Hogan patented this means. Another common ganging method was sliding sections of the tuning inductors together or apart by means of a rack. Many more radios were ganged using variable capacitors than by means of sliding inductors. Some manufacturers ganged only the second and third tuners, leaving the first tuner to cope with the antenna variability. Other manufacturers incorporated clutches on the tuner shafts to permit 'tweaking'.

Atwater Kent devised another means to achieve ganging. His method was coupling the tuning condenser shafts by using belts and pulleys. The first sheet of his patent, No. 1,668,155, is reproduced in Figure 36. The important technical contributions of men like John Hogan and Atwater Kent rivaled the work of giants. Review of the patent illustration shows several additional features. First, of course, the set is recognized as the early Model 30, No. 7950. The recognition keys were the UV-style tube sockets and the large coils. Another key feature was the size of the first audio transformer. The early version used the smaller diameter unit.

Comparison of Model 30 with the Compact 20 shows how the major changes incorporated in the Compact 20 anticipated gang-tuning. The shelf that was welded to the front panel of the Compact 20 to carry the tube sockets was easily extended by 2½ inches to carry another tube for the Model 30. It was also made deeper by about ½ inch to move the sockets away from the front panel. A second panel was used to carry the three condensers, instead of mounting them on the front panel, so they could be ganged with flexible bands. The second panel was fastened to the shelf with screws so that it was spaced about ½ inch behind the front panel, and in the space pulleys were fastened to each of the condenser

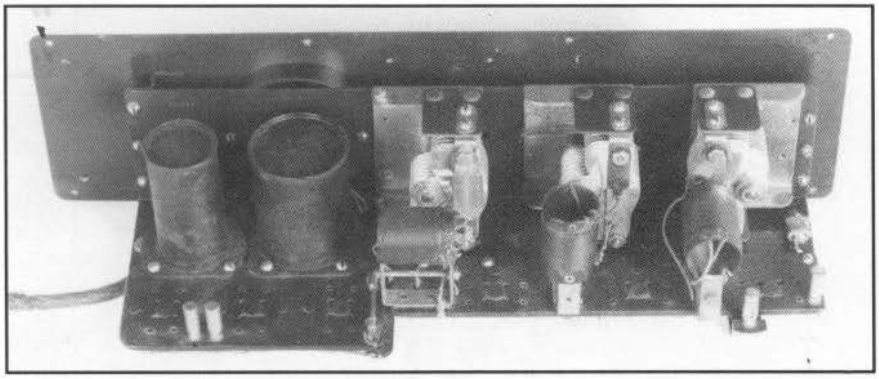


Figure 37. *Late Model 30. The tuning condensers were redesigned to eliminate the Bakelite frames and to mount them on a new sub-chassis.*

shafts. The pulleys, in turn, were banded together by phosphor-bronze loops so they turned together, with the shaft of the center condenser brought out through the main panel to give manual control over frequency selection.

Most collectors do not find Model 30, No. 7950 receivers whose ganging is still intact. Usually the belts are broken across the holes for the alignment pins. The cause is the destructive swelling of the pot-metal pulleys. Pot-metal was attractive for small intricate parts whose shape was expensive to machine. Apparently its major fault, extreme stress corrosion, was not recognized in the middle twenties. It seems impossible that a careful manufacturer like Atwater Kent would have used the material if that unfortunate property had been known to him.

The use of belts and pulleys for ganging required a means for tensioning the belts and adjusting the relative positions of the shafts. Belts on the Model 30 were tensioned by moving the outer condensers toward or away from the center unit. The condensers were then secured with screws passing through slotted holes in the support panel. The second panel was necessary to support the condensers instead of using the front panel (as on Model 20C) because of the slotted mounting holes for the outer condensers.

The early Model 30 used coils very similar to those on the Compact 20. They were secured using brackets fastened directly to the rear circular plates of the condensers. On the later Model 30, No. 8000, the coils were reduced in diameter and in length and mounted by different brackets to a Bakelite panel which also formed the sockets for the radio amplifier tubes. The later Model 30 was intended for use with UX tubes so the tube-pin springs were arranged to permit a sliding contact when the tubes were inserted and the bayonet brasses were eliminated.

Altogether, the resemblance between the early Model 20 and the early Model 30 was strong. Similarly, there was a strong resemblance of the later sets in each version except for the last Model 30. It is clear from the design and from the parts lists that many of the elements were common to both sets.

When Model 30 was introduced, radios were not built with excess gain that could be used to make up deficiencies in their circuitry or in the antenna system. Long, high antennas carefully coupled to the first amplifier stage were still the accepted method of capturing radio waves. With all the different ways that radio fans built and maintained their antennas, and with the strong influences of the different antennas on circuit tuning, special measures had to be taken with gang tuning to keep the first tuned amplifier working up to its capabilities.

In designing Model 30, Atwater Kent chose to use an isolation tube to separate the antenna circuit from the tuning system. He could therefore apply the Compact 20 tuning circuitry to the Compact 30 without change. The antenna was connected directly to the grid of an isolation tube with a return to ground through a close-wound choke. The output of the extra isolation stage was fed through the primary winding of the first inter stage transformer. This coupler had the same characteristics as the other two tuned transformers (particularly inductance and strays) so it was tuned by the same amount of capacity as the other stages.

Atwater Kent went directly from the three separately tuned circuits of the Compact 20 to the gang of three condensers in Model 30. Since these were originally taken directly from the big Model 20, it may be conjectured that part of the transformer-coil difficulty that led to producing the prototype big twenty in early 1924 was caused by anticipating the design of gangable tuning circuits. The word 'directly' is used to emphasize the point that the early work on the Twenties Series was so successful that the Model 30 was built using the same condensers, RF transformers, orientations, and spacings except for the old antenna transformer. That coil had to be modified slightly, because with the same orientation as it had on the Model 20, it had to be shortened by nearly an inch and rewound with smaller wire in order to fit into the mahogany box that housed the first Model 30.

Part of the fascination that keeps historians of the radio art chained to their studies is that, every once in a while, the artifacts will point to a human trait that is shared between the observer and the subject. Just such a quality is revealed by the cabinet of the first and second versions of the Model 30, which was also the one which was used on the Compact 20. Apparently at the time the Model 30 was ready for introduction, Kent felt that the sales of Compact 20s would drop, leaving a substantial

inventory of unused boxes. It appears that Mr. Kent was as much of a saver as most of us are today, particularly with our old Atwater Kent parts. Most collectors have heartburn over discarding just one cabinet, especially if it retains the original finish. The author sympathizes with Mr. Kent.

Because they were not quite deep enough for the Model 30, the old cabinets were changed in two ways; recesses were cut in the rear wall for the coils, and the old antenna and ground holes were plugged. New holes were bored in line with the untuned amplifier-stage terminals. While the cabinet with its changes was dramatic evidence of inventory reuse, it was only one of several. Altogether, there were four versions of Model 30 receivers, but only the first two used the Compact 20 cabinets. These were recognized by their name plates which had yellow-colored fill in the Atwater Kent circles. The first of the two versions used up the bayonet tube sockets from the Compact 20 stock, and was identified as Part No. 7950. The second used push-pin sockets and was identified as Part No. 8000. The similarity to the two compact 20s is strong enough to suggest that the idea of using up old inventory was a basic tenet in Atwater Kent's factory.

The first two versions of Model 30 were put into production in November, 1925, and were tallied in the production figures for 1926. Shortly thereafter, a third version was produced, which merely replaced the old too-tight cabinet with one about 3/4 inch deeper. It was given a different nameplate, this time with an orange fill in the Atwater Kent circle. The sockets were the same as those of the second version, the push-pin type. Whether the part numbers mentioned above followed the socket style or the nameplate color is problematic, because the published parts lists carry only Part No. 8000 for all three versions. The production figures also incorporated this version into the total count of 99,000.

The 4th version, Part No. 8000-A, Figure 37, was substantially different in the mechanical design of its radio amplifier. The variation was not large enough to generate a new model number, but neither was it small enough to keep the old one. A compromise resulted in its identification as Model 30A. A new set of smaller coils and a new construction of condensers that were free of expensive Bakelite castings formed the basis of the new design. Because of the use of the new RF-amplifier design on subsequent sets, e.g., Model 35, it will be described when that set is reviewed. The rest of the Model 30A; the cabinet, the detector-audio amplifier, the general performance, and the nameplate, remained the same as those in the third version. From the outside, the Model 30A was quickly recognized by the larger medallion on the front panel and the way the rheostat unit passed through a large hole punched in the front panel.

Available information on production quantities does not tabulate Model 30A explicitly. Because of its introduction so late in 1926 (November), the author assumes that the production figures for 1927 imply the Model 30A. There may have been a few of the third version of the Model 30 included in the listed quantity, but the number must have been small. The 1927 quantity was 21,500 radios, making the total of all the versions of Model 30 cabinet sets a few more than 120,000.

Extending the use of parts from one series of receivers to another was a common practice for Atwater Kent. Because Model 30 followed directly on the heels of Model 20, it was introduced on the manufacturing floor probably by minor variations of Model 20 techniques. Conversion from one to the other must have gone fairly easily. This is borne out by the production figures and the introduction dates. Model 30 was introduced late in November, 1925. In 1926, a few sets short of 100,000 were produced. The figures for early Model 20 compact receivers in 1926 show none manufactured. Only the late version of Model 20C was produced. Apparently the hardware for the early version of Model 20C was absorbed by the early Model 30 sets.

In addition to the cabinet models, Atwater Kent produced panel-only Model 30 sets for use in cabinets different from the table set that Kent made and sold. Furniture manufacturers like Pooley installed the panel sets in consoles and other furniture. In all, about 49,000 Model 30 Panel sets were made. The part number for the first panel was No. 8186 and in 1926 nearly 30,000 were produced. Model 30 continued into 1927. The panel set got a new number, No. 9043, and 19,800 of these were manufactured.

Atwater Kent's production history seems, in some ways, to accord nicely with our present-day experience. But things don't always go smoothly, even in stories, and some of Kent's sets do not fit into their expected places. Model 5 was an example. By the time it was released, Model 5 had become an anachronism. Model 48, No. 9640, has the same puzzling character. While not a variation, the Model 48 was the same set as Model 30 but it was produced in a different run, and about two years later (1929). Some Model 48 sets were equipped with gold-painted panels, perhaps reflecting upgraded modern decoration in keeping with the metal-cabinet sets. But then, some were identical to the 30 series with brown panels. More puzzling is the fact that Model 48 appeared in two variants. The early one resembled the first version of Model 30 with bayonet sockets, and was identified by a blue-background nameplate.

The second version was like the third Model 30 with push-pin sockets, but it had a gold nameplate. However, both versions of Model 48 had the deeper cabinet that was first used on the third version of Model 30. (Kent had finally run out of those old 20C cabinets.) Perhaps the market

for battery radios continued at a high enough level to justify another production run for each set, but if that were the case, why wasn't the design of the fourth version, Model 30-A, used as the basis for Model 48? Could it be that there were parts left over in those stock bins? It is tempting to say that the Bakelite mounted condensers and the double panel to carry them were still in stock.

MODEL 32, No. 8270

The success of Model 30, in its several versions, encouraged Atwater Kent to produce an upscale radio following the pattern set by the Model 10 and the Model 12. Experience had shown that more audio amplification did not achieve the goal of a better radio. In the middle to late twenties, the quest for more amplification in a receiver using triodes always led back to the RF amplifiers. Part of the reason derived from the characteristic of the grid-leak detector. The rest was in the limitations of the audio amplifiers. Grid-leak detectors could do fairly well over a wide range of signal amplitudes, but did especially well with input-signal amplitudes approximating one-half volt. With this signal amplitude, outputs ranged from one to two volts, making unnecessary a large amount of audio amplification to reach loudspeaker levels.

Audio amplifiers produced mid-frequency voltage gains of from 10 to about 15 times per stage, a good average value being 12 times. Two stages produced more than enough amplification to operate a loudspeaker from the detector's best output. When additional stages were used, high signal levels resulted in severe distortion, and coupling from the output (loudspeaker) circuit to the detector plate circuit through a partially depleted battery supply was often enough to produce audio oscillations. In later days, bypass capacitors were used to control this coupling, but in the mid-twenties the choice was to limit the amount of audio amplification. Increase in the overall sensitivity, therefore, put the demand on the RF amplifier section of the set. By 1926, Atwater Kent's engineers had standardized the RF circuit elements. They found the characteristic voltage gain of each of their designed radio amplifiers ranged from five to eight times. Tuning was accomplished using rotatable, meshing condensers and fixed coils. Kent chose to not use the Neutrodyne circuit although it was very effective. (It reduced feedback coupling in both the inductive mode by carefully orienting the coils, and in the capacitive mode by balancing out the plate-to-grid capacity of the tubes with the Neutrodon condensers.) Atwater Kent had standardized on the orthogonal-coil arrangement to limit inductive feedback, and used damping resistors to limit the effect of tube-capacity feedback. Therefore he didn't license the Neutrodyne

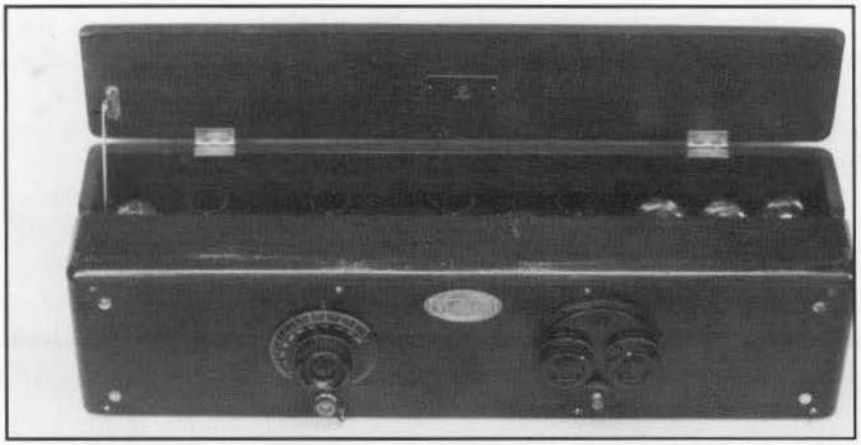


Figure 38. *Model 32. A peek at the binocular coils that replaced the solenoids in Model 30 may be seen just over the fixed top board of the cabinet. These offered more isolation than the orthogonal arrangement.*

patent, but his stage amplification was limited to about six times. The number of amplifiers was still open to choice, but because of the orthogonal limitation only three coils could be used. Consequently only three amplifiers could be tuned.

Up to Model 32, Atwater Kent held the number of radio-amplifier stages in his receivers to two. Model 30 and Model 35 used another tube (making three RF stages), but the function of the extra tube was antenna isolation. Model 32, No. 8270 was the first set in the series to provide the full third radio amplifier, including a tuning condenser and its resonating coil. Model 32, No. 8270, Figure 38, was released in May of 1926. It had strong similarities to the third version of Model 30, but it was more sensitive because the extra tuned-radio-amplifier stage had been added. Model 32 incorporated three RF amplifiers, an isolator stage and a detector, and all four of the inter stage coupling transformers were gang-tuned. The big difference between this set and all the earlier ones was in the design of the RF transformer coils. On Model 32, the transformer coils were parallel pairs.

Coupling between the radio-amplifier stages, in receivers as compactly built as the Atwater Kent mahogany-box receivers were, was predominantly inductive and was excessive for stable operation, unless the design of the coils included steps to specifically modify the interaction of the coils. Reduction of that coupling was accomplished in the later Model 10s, the 20s, and the 30s by orienting the coils orthogonally. Model 32 used another method, coupled parallel coils, where the field of one coil in a parallel pair was somewhat confined by the action of its adjacent mate. Instead of the large coils mounted on the condenser back plates, typical

of the Model 20 and the early Model 30s, or the smaller coils of the late Model 30 and the Model 35, a new design using two parallel coil forms for the grid winding was introduced in Model 32. Other manufacturers using this same arrangement gave special names to their application. Grebe, for example, referred to the coils as "binocular."

The purpose of the dual form was to restrict the field in the space outside of the coil proper. In the solenoid like those on Model 30 nearly all the lines of flux pass through the volume of space surrounding the coil. In a toroid, significantly fewer lines escape from confinement inside the winding. The dual coil was a compromise between the two. Its field was better contained than that of the solenoid but not nearly as well confined as in a uniformly wound toroid.

Why was this important? Because the amount of field from one coil, that was linked by the turns of another coil, determined the coupling between the coils. Not only was a receiver's individual stage gain limited because of this kind of coupling, but the number of stages was even more severely limited. An improvement in the means of confining the field meant both increased gain per stage and an increased number of stages. The latter was important because coupling from the detector to the antenna transformer (section gain) was much more of a problem with high RF amplification and feedback than was direct single-stage feedback. With the dual coils, the coupling was greatly reduced and Atwater Kent was able to eliminate the orthogonal coil orientation (only three coils possible) and use four tuned-amplifier stages.

The primary of each transformer was wound on a short coil form and located inside the first segment of the dual coil (nearest the condenser.) It was coupled tightly to the cold end of the grid coil giving sufficient induction to assure signal transfer from plate to grid, even though its coupling to the second segment of the dual coil was nearly zero. The grid coil wound on each segment was resonated by the tuning condenser for each stage, with the lower (hot) end of the outer segment coil connected to the grid of the next stage through a damper resistor of approximately 860 ohms. The result was that the external field several inches away from the pair was too small to cause difficulty in neighboring pairs. Consequently, all pairs could be mounted on the variable condensers without concern about their orientation.

Today, the calculation of binocular transformer parameters, e.g., field confinement, coefficients of coupling of mated coils and of adjacent pairs, and effective turns ratio can be done quite precisely using computer approximation techniques. Before computers, reasonably accurate estimates could be made using empirically established formulas, but in the mid-1920s the only practical way to design binocular transformers was with

experiments on real parts. In the design of the radio-frequency-amplifier section of Model 32, the Atwater Kent laboratory was assigned a very difficult problem, especially because of the ganging of the four tuned-transformer stages. The people who solved that problem must have felt good about their work when the design survived into the day of the electric sets.

Comparison of the circuit of Model 32 to that for Model 30 shows the sets to be identical except for the one complete radio-amplifier stage that was added to Model 32. Both had the isolator stage with non-resonant chokes in their antenna circuits, and both used identical detector and audio-amplifier circuitry. Direct comparison of the sets themselves leads to differences beyond the extra amplifier, depending on which variation of each is examined. The first Model 32 was very close to the third Model 30, with the one immediately obvious difference, the RF-transformer design.

The use of four tuned stages meant an increase in the size of the Model 32 cabinet over that of the Model 30. The increase was 4 inches in the width of the set, about the width of one radio stage. No change to the other dimensions was made. Model 32, No. 8270, measured 24 inches wide by 6 inches high by 6½ inches deep. To provide the ganging for the condensers, a third belt was added. The driver pulley was the second from the left, and belts identical to Model 30 (and Model 35) were used for the first and third condensers. A new belt nearly twice as long was used to couple the fourth condenser to the second. It ran on top of the belt for condenser number three.

Adjustment was accomplished in the same way as on the earlier sets, by loosening the condenser-fastening screws and sliding the condensers apart as required to get proper belt tension. Then, in order to synchronize the tuning, a signal, preferably at the high-frequency end of the band, was tuned in. Each rotor was loosened, using the pulley-securing screws, and rotated as necessary to maximize the loudness of the signal.

Model 32 was not intended for the general market. It was more sensitive than Model 30 and therefore aimed at a more limited application—technically, where signal levels were comparatively low and reception was difficult—but from its price, at the top end of the market. The Model 32, less tubes and speaker, was sold for $140. This was substantially more than Model 30 at $85, and twice the price of Model 35 at $70. Altogether with tubes, speaker, batteries, and an aerial, the Model 32 cost a prospective purchaser nearly $250.

Model 32 was also sold as a panel set with no cabinet. This unit was used by other manufacturers, like Pooley, for incorporation in their receiver line and sold through their distributors and dealers. The panel

version of Model 32 was No. 8280. Its design and assembly were identical to No. 8270, the table model.

The total number of both versions, the cabinet and the panel sets, was almost exactly 38,500, of which all but a few were made in 1926. The whole production run was completed in less than a year. At the same time, other 30-series sets were being made in much larger quantities. This indicates that Model 32 was a specialty set offering the extra amplification to listeners who could receive only weak signals or to those customers who would only accept the best.

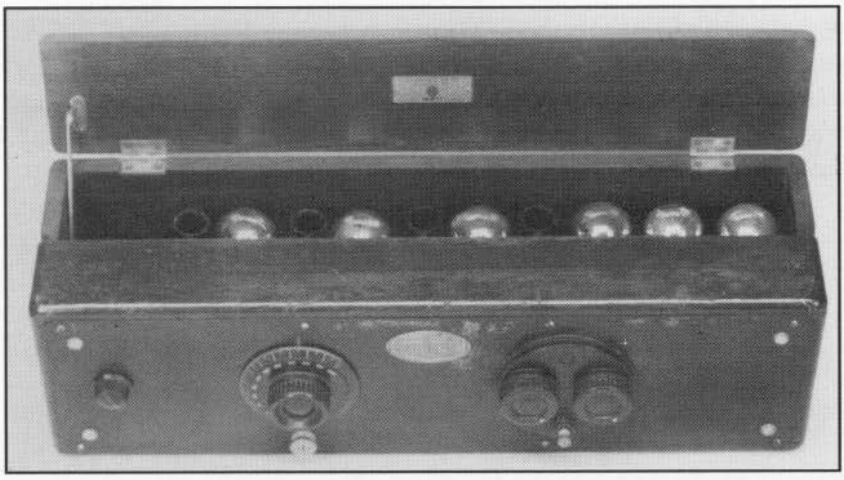


Figure 39. *Model 33, Front. This set combined the tube count of Model 30 with the tuning of Model 33 and added the 'tweaker' (left knob) to eliminate the need for the isolator stage.*

MODEL 33, No. 8930 — PANEL SET No. 9050

The electrical design of all of the Atwater Kent receivers was stable in 1926 and 1927; their circuit modifications from the Model 10 series were not major. The circuit of Model 33 was almost identical to the Model 30. Mechanically, the receiver was a near duplicate of Model 32, combining the four tuning capacitors of Model 32 with the stage line-up of Model 30. The distinguishing feature of Model 33 was the antenna-adjustment condenser and its knob on the left side of the panel. Figure 39 shows the front view and Figure 40 the rear view. In identifying the set, a single look at the pictures lets the collector eliminate all the other battery sets, and just a little more information permits complete identification. A gold panel indicates it is a Model 49, and a power unit would reveal the radio as Model 36. (The pictures were made of a Model 49 receiver, not a Model 33). The circuit diagram shows the input to be

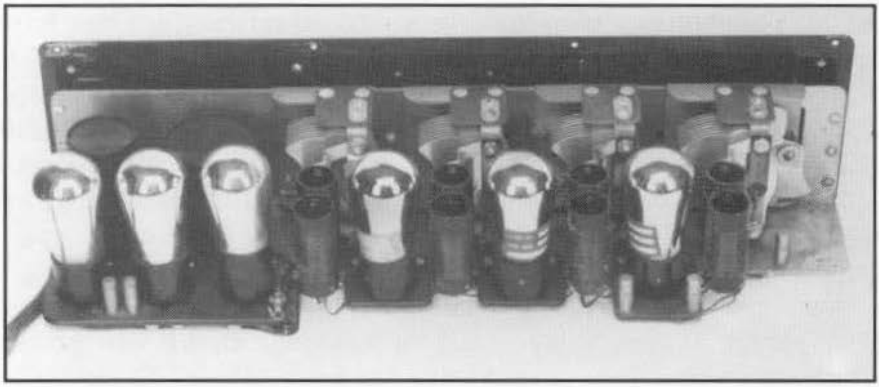


Figure 40. *Model 33, Rear. The sub-chassis that carried the condensers, the binocular coils and the tube sockets was a major manufacturing improvement in the Thirties Series.*

a radio transformer. This was the best choice for the input stage from the standpoints of voltage amplification and selectivity but a poor choice (without the antenna adjustment) for tracking the set's tuned frequency with dial position. Electrical detuning was caused by the antenna which had to be coupled closely enough to efficiently transfer its energy to the first-amplifier grid circuit.

The impedance of the antenna was low, while the impedance for best design of the grid circuit was high. Of course this indicated the use of a transformer. Ganging requirements made the use of the inter-stage transformer in the antenna circuit very difficult. The antenna was not only low impedance but also capacitive. This capacitive effect was transformed along with the signal energy, causing the required condenser capacity to vary from the amount used with the inter-stage transformers, depending on the antenna. By adding a trimming condenser in parallel with the main condenser the effect of the antenna could be balanced out. Figure 41 shows the trimming condenser, a single movable plate meshing with two fixed plates attached to the main stator stack.

The other antenna feature of Model 33 was the tapped transformer primary, reminiscent of the Model 10 and the Model 20. Customers with a short antenna used the low-ratio tap (up further on the primary coil) and those with long antennas used the high-ratio tap (nearer the lower end of the coil.) The rear view shows the two antenna terminals; the short antenna connection is on the left.

The Model 33 was a transition set. It stood between two construction techniques; the panel-supported parts arrangement used on Model 20 and the early Model 30, and the subpanel arrangement of Model 35 and the later bathtub receivers. The rear view shows the attachment of the subpanel to the front (dress) panel. This panel-attachment design was

also used on the last variation of the Model 30-series which was being produced in 1927 after its successful production and sales record of 1926. Model 32 used four tuning condensers mounted on a subpanel. Model 33 also used four tuning condensers, but they were mounted on a larger "L" - shaped subpanel which also carried the other parts such as the sockets and the audio transformers. Model 32 used the older-style shelf welded to the front panel as the means of attaching its parts and the subpanel with its four condensers.

Earlier sets such as the Model 20 had only three tuning condensers. When Model 30 came along, the three-condenser circuit was retained but the condensers were ganged using two belts. Model 32 and Model 33 added a condenser and that made a third belt necessary. Inspection shows the four pulleys and the three belts.

Although a second double pulley and short third belt could have been used, Atwater Kent chose the longer belt even though it over-traveled the second belt. The reason is found by examining the overall production process. When the set was sent to the test station for tensioning the belts and aligning the radio amplifier, independent adjustment of each condenser was a great time saver. While the parts cost was higher than the minimum possible, the alignment time and its consequent cost was reduced. Figure 40 also shows the slots for the outboard condenser-attachment screws that let the technician tension each belt separately. Then, with the outboard pulleys loosened from their shafts, frequency synchronization was quickly completed by rotating the individual condenser shafts in their pulleys, which were held in a fixed position by the belts and the double pulley on the second-condenser shaft.

Model 33 used four tuned, double radio-frequency transformers, one of which used the tap for long or short antennas. Otherwise they were identical to one another and very similar to those on Model 32. The three amplifier stages and the detector were tuned by newly-designed ganged condensers that were similar to those used on the Model 30A. They were mounted on an L-shaped sub-panel about 20 inches wide, which was screwed to a pair of brackets that were welded to the back side of the main panel. This, too, was similar to the arrangement of Model 30A, but four inches wider.

The shaft of the trimmer was brought out near the left end of the main panel. A small uncalibrated knob enabled the listener to trim the Model 33 for maximum sensitivity if that was needed, or to use the trimmer as a primitive volume control. The trimmer was a single plate that rotated alongside the stator of the first tuning condenser.

The Model 33 table set was about 21¼ inches long with the same cross dimensions as Model 30 and Model 32: six inches high and 6½

inches deep. It was longer than Model 30, but shorter than Model 32. This reflected the number and style of the tuning condensers. Model 33 used the new style metal frame condensers that had also been incorporated in the Model 35 and the last of the Model 30s. The rear view Figure 40 shows the new condensers. These could be put on 3¼-inch centers as compared to the four-inch centers used on the earlier sets. The "L" shaped panel with its four smaller condensers and better mechanical stability, independent of the dress panel, foretold a new series of Atwater Kent receivers.

Model 33 was introduced in May of 1927. By the end of that year 70,000 had been produced, along with more than 38,000 of the panel version. Model 33 was the last of the battery-operated, mahogany-box Atwater Kent sets. It successfully replaced the Model 30 series by providing more sensitivity, with the same number of tubes, at only a small difference in price. It listed for $90, while at the same time the Model 30 sold for only $10 less at $80. The year before, when Model 32 was at the top of the line, Model 30 was sold for $85 and Model 32 was listed at $140.

In 1927, two versions of the Model 33 were produced: a table set and a panel unit. The table model, No. 8930, was introduced in May with a little over 70,000 built in the remainder of the year, an average of ten thousand a month. The Model 33 was also produced as a panel unit for incorporation in a console. The panel set was No. 9050, introduced at the same time as No. 8930 with nearly 39,000 units produced during the remainder of 1927. Whether or not Atwater Kent had started making complete console receivers under his own name is not known positively by the author, because no indication by set number or model has been found. However, he did make the panel units available to other cabinet manufacturers such as Pooley and Red Lion for incorporation in consoles bearing their brand names. Arrangements with Pooley had started with Model 10 more than three years before the Model 33 was released.

Collectors today recognize the Model 33 as a good performer. Model 33 was successful in another way. It provided the basis for the other major development in radio operating convenience, house power instead of batteries. No major changes except for tube types were required to adapt it to alternating-current operation. One more major change, electrical in nature, was necessary before the new series became the product line. It was "socket power" instead of battery power. Model 33 was the set that introduced the alternating-current receiver into the Atwater Kent line. The radio chassis was modified very slightly, a power unit was added, and a model number, 36, was assigned to the new set. With a power-supply unit it reappeared in the Atwater Kent line for 1928 as the Model 36.

Atwater Kent was known by his employees as a strong manager who often visited the assembly area of the factory. He made close observations of the products and processes, and insisted on improvements where efficiency could be increased. Former workers from the Atwater Kent factory portray him as "Mr. Kent" and describe him as meticulous but fair, but there was an emphasis in his demands that assured attention. Atwater Kent also revealed a paternal side to the factory. While he was demanding of his factory force, he was also sensitive to their concerns, never treating them as hirelings, but showing direct awareness of them as people. It could be said that he felt, and possibly understood, the impact of workers' attitudes on production effectiveness. While such an approach might be explained as clever exploitation of the work force, the lingering memories of his people add a more personal, more human flavor to their contacts with him.

Atwater Kent was an excellent engineer. The title "Engineer," when used to describe achievement of completed formal academic program, is applicable to neophytes, not those experienced in practice. Engineering is the directed application of technical precepts in the definition of material things for the benefit of people. By this test, Atwater Kent stands high on the hill of engineering achievement. His working life was spent finding problems, particularly in the electrical field, defining (and inventing) solutions, and seeing them converted into the devices that served their users so well that the world made his name into a household word. The catalog of Atwater Kent's ignition and radio achievements is long. None, however is more interesting than the problem of the wooden box.

Atwater Kent Jr. has told us that his dad did not like using veneered wooden cabinets for his radios. The younger Mr. Kent said that his father was continually advised by the marketing staff about customer demand for wood as the blending material in home decoration, but sought ways around that demand because of his preference for metal enclosures. An argument could be made that Mr. Kent disliked wood for some aesthetic reason and was prejudiced against its use in his products. The argument is weak when one considers that he used wood for his early ignition-equipment containers and that he based his Open Sets with wood (which Atwater Kent, Jr., told us his father really admired), and produced the solid-wood boxes of the Twenties and Thirties series. A better argument can be made that Kent was fascinated with stamped steel for cabinets.

Another strong argument can be made by considering the cost of using wood as the cabinet material for an electrical device. The engineer in Atwater Kent would consider the cost as a primary factor, the availability

of a suitable metal-fabrication process next, and then the customer demand. He would have been challenged by the problem of forming an aesthetically satisfactory metal box.

Because the factory was, to a large extent, built around metal processing, and had to obtain wooden consoles from outside (e.g. Pooley), there was also a tendency to utilize the metal fabrication to its fullest extent. Atwater Kent believed that the public would accept the metal instead of wood for a radio cabinet. Model 35 resulted from the search for a metal-cabinet design that had a pleasing shape and was a suitable decoration to be a harmonious companion to the living room furniture of the 1920s. It was sold for $15.00 less than its twin, the Model 30. In the first production year, its price was $65.00. In 1927, the prices of both sets increased by $5.00, but the $15.00 difference was maintained. Because the only difference between the sets was the enclosure, it must be concluded that the wooden cabinet accounted for the differential, almost 1/5 of the price of Model 30. Atwater Kent was clearly correct in his view of engineering, i.e., making a better product available for less customer-cost, based on utility. To those potential customers who admired wooden boxes for shape and finish, he wasn't so right. But because he maintained the Model 30 concurrent with the Model 35, he also served the wooden-box market. With the judgment of the buying public reflected in the sales figures, he must be recognized as meeting his market, and noted as a competent engineer.

In looking at the first part of the 1920s and recalling the almost revolutionary means that Atwater Kent had already used to shape steel and to reduce manufacturing costs, a historian is led to ask what came next. The new ways that machine tools were being used in the automobile industry would have influenced Atwater Kent to use them in his factory. His market perception and his business acumen would have guided him to make a marked excursion from the waning style of contemporary radios. Model 35 exemplifies these influences superbly, by showing how a new art form constructed from new material on efficient new machinery found a secure place in the public's affection.

In the middle 1920s there was an acceptance in the United States of machine-shaped steel that was almost a love affair. That came about in part because automobiles went from coaches made with wood in their structures to large panels of contoured steel that were welded together to make complete bodies. It was a time when stoves changed from cast-iron affairs, that had been in vogue for cooking since women stopped kneeling at their fireplaces, to ranges made of stamped-steel panels. It was the time when the refrigerator with its dramatically shaped steel compartments replaced the ice-box. Without stamped, punched, and shaped steel none of these benefits would have been available to change the way of life of



Figure 41. *Model 35 with Sign. As a sales aid, the lighted sign on top of the radio was made available to dealers. Its frame was fitted exactly to the ridges in the stamped case of the radio.*

the general public. Atwater Kent recognized that this technology could and would be used to make a modern radio.

The advances that were wrought in appliances and automobiles would not have come about if the public had not been ready for major changes in style. A revolution in clothes, in art, and in architecture was quietly taking place. Radios in wooden boxes that had offered the traditional comfort of familiar furniture could be displaced by unfamiliar shapes and finishes. The era of popular art-deco was just around the corner, and Atwater Kent recognized that a new style for radio receivers would have great appeal. When viewed from the vantage of the user, Model 35, Part No. 8100, presented an entirely new appearance for a radio (Figure 41). The soft curves of its case, faintly reminiscent of the ogee that marked the breadboards, but given a modern touch by the vertical section between the curves, was a sharp contrast in style to any of its predecessors in the Atwater Kent line. Although its shape was unique insofar as any other receiver was concerned, the way the nearly flat top flowed into the sides and the way the bottom flared to join the plane of the supporting surface may be found in some of the minor dress panels of contemporary automobiles.

Had the shape that distinguished the Model 35 been very difficult to produce, it might never have been brought to market. The opposite was true; the shape was moderately easy to draw using ductile sheet steel. Because the depth of the Model 35 case was about equal to its height, the draw to make it was considered deep. This meant very careful control of metal stretching and called for several separate steps. The corners probably determined how difficult the drawing process was and consequently how much the drawing dies cost. Briefly, the steps would have been;

stamp out the blank, about 18 by 29 inches; make the first draw to get a pan, 12 by 23 inches and three inches deep; make the second draw to get a box near the final size; make the third draw to come to the final size and flare the edge. Finally, several piercing steps had to be performed to punch out the holes in the sides for the dial, the connections, and the filament control.

Since each of these steps was done on a separate press, and since the process was quite different from the simple stamping, piercing, and folding required for the other models in the 30 series, the investment in new presses and dies must have been very large. As many as 20 different presses were required to perform all the sequential steps necessary to make the Model 35 case, and another ten were needed to fashion the other parts such as the brackets, the bottom, and the condenser sub-panel. Altogether, a minimum line of 30 presses would have been set up for one complete cycle. If the presses could each have produced one stroke per minute for a full eight hours, they would have piled up a few less than 500 cases in one day. In a year at that unbelievable rate, 125,000 sets would have been produced. But in a single year, 1926, 200,000 Model 35 radio sets were manufactured. To meet that production, along with the other sets that were manufactured at the same time as the Model 35, more than 100 presses must have been on line and running at their optimum rates.

The factory buildings on Stenton Avenue in Philadelphia had been expanded to accommodate the increased production of Open Sets before the erection of the new factory on Wissahickon Avenue in 1923. Before the inception of the Twenties Series receivers, Stenton Avenue was used for accessory production, with the main lines being set up in the new factory. When the changeover from wood to metal for cabinets was performed, the new machinery, predominantly presses and painting facilities, was installed in Wissahickon Avenue. By that time the building had almost reached the level of efficiency that was anticipated for its use. It contained the laboratories, the offices, shipping and receiving and production facilities for Models 30, 32, 33, 35 and 36. Preparations were underway for manufacturing Model 37 and Model 38. The building was so extensive (more than 15 acres) that Atwater Kent drove his visitors around in an especially-built electric car.

Model 35, No. 8100, was introduced two months after Model 30, in January of 1926. Production of Model 35 in that year was just 56 sets short of 200,000. The improved version, No. 8100A, was introduced in November, 1926, for production in 1927, when 122,000 sets were manufactured. In 1926, a total of about 450,000 Atwater Kent receivers were sold. Of these, Models 30 and 35 accounted for nearly 330,000. Model 20 and Model 32 made up the difference.

Model 35 gave good value for its price, but it was not free of problems. Some amount of tube balancing was necessary to get volume control using the filament rheostat and sensitive radio-frequency performance. By putting the higher-emission tubes in the audio amplifiers and the low-emission tubes in the radio section, starting at the antenna circuit, good volume control could be easily obtained. The other problem concerned the pulleys on the tuning condensers.

An earlier segment of this series mentioned the problem of the Model 30 ganging pulleys. Because Model 35 used an identical radio-frequency amplifier and was built in the same time period as Model 30, it suffered the same problem with the pulleys. The metal cracked and expanded out of shape until the bronze belts broke. The cause was called stress-corrosion, a characteristic of the metal alloy from which the pulleys were made. An alloy which combines a high coefficient of thermal expansion (the tendency to get larger with increasing temperature) with low tensile strength (the tendency to break when pulled) will fracture when subjected to repeated heating and cooling. The diurnal temperature cycling that occurs in most storage areas causes the damage. Unfortunately, material testing for fatigue and stress corrosion was not common in the 1920s so many of the inferior metal combinations were unwittingly used for parts. Such combinations were rejected when their properties were recognized. Atwater Kent substituted brass for the early pulleys, starting with the last versions of Model 30 and Model 35.

One-dial tuning was introduced with Model 30. Its fourth version, Model 30A, was the same electrically as the others, but was built with a substantially-changed mechanical design. Model 35 was almost identical to the Model 30A, and both were designed around a new L-shaped sub-chassis. This new chassis was made about two inches narrower than the welded shelf of the other versions of the Model 30. It carried all the internal parts of the receiver, including the rheostat unit, and was screwed to welded brackets on either end of the front panel of Model 30A or the case of the Model 35. The earlier Model 30 condensers were replaced with a new design based on a single stamped and folded end plate. Only one rotor bearing was used, but it was strong enough to cantilever the rotor. With no rear end plate, the radio-frequency transformers had to be mounted independently of the condensers. This was accomplished by molding a thin Bakelite strip for the three radio-amplifier tubes, leaving enough space between the tubes for the transformer mounting brackets. The coils of these transformers were also changed to reduce their diameters and to decrease the size of the winding wire. The transformers were still arranged orthogonally, with the direction of each coil the same as before.

Model 35 was identical to Model 30 electrically, except for the filament circuit of the detector tube. In Model 35, the detector filament was connected

to a fixed resistor along with the two audio-amplifier filaments. Only one variable resistor was used in the set. It served as a volume control by reducing the emission of the radio-amplifier tubes. The circuit diagram for Model 35 is usually given as that of Model 30, with a notation about the detector-filament connection.

The use of the L-shaped chassis ushered in a new approach to radio manufacturing. A major styling change, intended to meet the changing market trends, no longer implied a redesign of the entire receiver. By making the internal operating elements of the receiver completely separate from the case and its appearance items, Atwater Kent put into practice a concept that later emerged as the chassis-and-cabinet configuration of all radio sets. This idea is not startling until the collector considers that virtually the same chassis, designed in 1925, appeared in Models 37, 40, 41, 42, 43, and several others in 1927 and 1928.

In designing the Model 35, the case was made just wide enough to accommodate the internal chassis. Model 35 was therefore the smallest TRF radio set produced by Atwater Kent in the 1920s. Its internal arrangement was similar to Model 30A except that everything was upside down. To avoid the bad effects of a rough edge on the flare at the bottom of the set, a rectangular base was designed. It fitted closely inside the case, and had a smaller rectangular opening to give access to the tubes. Four pads in the corners of the rectangular base protected the surface on which the radio was used.

Four versions of Model 35 were produced. The first two had cases that were pierced on the left side for the power cable and on the right side for the antenna and ground wires. The nameplates had orange fill in the Atwater Kent circle. The difference between these two was in the decorative buttons in the corners of the top of the case. The first version used the same milled-edge, circular buttons that had been used on all sets since the big Model 20. The second and later versions of Model 35 were fitted with a new button design that incorporated the curved-square motif that characterized Model 35. The last two versions had cases in which the sides had no holes. On these, the power cable, the antenna and ground wires, and the speaker wires came through holes in the rear. These rear-hole versions had nameplates with yellow fill in the Atwater Kent circles.

There was another difference among the four versions of Model 35; the number of plates in the variable condensers. In the first three designs, the total number of plates in each condenser was 13. In the last, which had serial numbers higher than 900,000, the condensers had 17 plates. Since all the sets tuned the entire broadcast band, the transformers must have had different inductance in their grid coils.

Radio historians, looking back at Atwater Kent's production, accord to Model 35 another recognition. In 1927, Atwater Kent made his millionth radio set. To commemorate the occasion, the receiver was presented to the President of the United States, Calvin Coolidge. The millionth receiver must have been made in early 1927, since the factory totals for the years up to and including 1926 were almost 985,000. In 1927, 122,000 additional Model 35 receivers were produced, along with the popular battery set, Model 33. Model 35 was the precursor of a new family of Atwater Kent radio receivers, the metal boxes, Models 38 through 47. Before reviewing them, one more radio receiver, the transitional Model 36 and its power supply, Type-Y, will be examined and described.

POWER UNITS — TYPES R, S, AND POWER SUPPLY TYPE Y

The transition from batteries to socket power for operating household radios did not happen all at once, even though to the present-day collector the change does not seem gradual. By 1926 the operation of a radio had become a matter of simple station tuning and volume adjustment. Single-dial sets had removed the annoyance of synchronizing several dials or fussing with regenerators. One last difficulty remained; using batteries to operate the radios. The elimination of batteries started in 1924 with the introduction of auxiliary equipment to supply "B" voltages. The end of the period came in about 1927, when nearly all manufacturers had stopped offering battery radios for general sale to electrified homes.

The use of "A"-batteries was messy for most homes even if the battery was kept in the basement and connected to the radio through a long cord. Some time before 1925 the home A-battery charger had been devised. Its use removed the necessity of taking the A-battery to a nearby charging station like a local automobile garage or radio service shop, but did not clean up the messy effects of wet cells and their acid.

"B"-battery usage was cleaner but not less of a deterrent to effective radio growth as B-batteries were very expensive. The operation of a three-dialer several hours each night for a month could amount to a day's pay for an average American in the mid-twenties. Aside from cost and the annoyance of having to replace the B-batteries every two months or so, the radio did not play as well toward the end of battery life.

The year 1926 saw the proliferation of B-eliminators. These devices brought "socket-power" to radio. They were a half-step between batteries and the full electric set. A-eliminators were also available but were not nearly as popular, probably because the rectifiers were not very efficient and the condensers needed to provide sufficient filtering were cumbersome and expensive. Instead of eliminating the A battery, another arrangement became popular. A trickle charger was left connected across the A battery,



Figure 42. *Power Supplies. These units were offered to reduce the expense of B Batteries by transferring a part of the operating cost to the much cheaper household electricity. They were used with receivers up to and including Model 35.*

but the charger had to be turned off during radio operation because of the excessive rectifier hum. In some B-eliminators the A-battery trickle charger switching function was accomplished automatically when current was drawn by the receiver.

Although other kinds of rectifiers had been tried, for the transition from batteries to socket power tubes offered the best performance and cost. Rectifier tubes of two kinds were developed, cold cathode and thermionic (hot cathode.) Cold-cathode rectifiers penetrated the B-eliminator market extensively. The common form was the BH tube, a product of Raytheon. It was derived from the S-tube produced by American Research and Development Corp. (AMRAD). A higher-current version, the BA tube, was also found commonly in higher-capacity applications. The BH tube was reliable and effective, and therefore offered very strong competition to the thermionic rectifier.

Atwater Kent felt the pressure of the radio market for eliminating batteries. He brought out the Type-R, B-Power Unit, No. 8800, Figure 42. Based upon the way part numbers were assigned and their recorded introduction dates, the Type-R B-Power Unit must have come out early in 1927. By that time, many other manufacturers had marketed B-eliminators, and Kent was clearly not the leader in providing one. Atwater Kent used another form of the cold-cathode rectifier in the first B-Power Unit that he offered for sale. It was a glow tube similar in concept to reference tubes such as those in the VR-75 to VR-150 family. Atwater Kent called

the rectifier No. 607 but carried it as Part No. 8750 in his numerical parts lists.

The action of the tube was to ionize its internal gas which then acted as a unidirectional conductor or rectifier. The pointed electrode, which acted as the cathode, the source of electrons, was tipped with a rare metal to aid in emission, which resulted from a high electric-field gradient rather than high temperature. The high gradient was produced by the sharp point of the electrode. The other electrode, the anode, was formed by a wire helix which maintained a very low electric-field gradient. In operation the tube lit up with a violet glow suggestive of the VR-150. This may be more than coincidence, since the author's No. 607 tube operated at about 175 volts. It is hard to believe that this tube would produce a good rectification characteristic, because its strike potential was greater than 230 volts, as measured on the author's tube. Such a high voltage would require very large filters to remove the high strike transient. Results using this tube were not sufficiently attractive, from a production standpoint, to justify its continuance as the basis for subsequent power-supply designs. Altogether, the B-Power Unit was not a very satisfactory product for its purpose when compared with the other B-eliminators available on the radio market.

The author conjectures that the B-Power Unit was a stop-gap product that was put out to meet the demand of distributors, dealers, and listeners, but which was not the factory's choice as the right way to go for technical development. Nevertheless, the demand was so strong that listeners in areas having 25-cycle ac service also had to be attended. The Type-S B-Power Unit, No. 9000, was brought out for use on 25-cycle (Hertz) power systems. The only difference between the two units was the power transformer which, while it performed the same electrical function, was different in its magnetizing current characteristics.

Atwater Kent did not produce an A eliminator. Instead, he incorporated a change-over relay in the B-Power Unit to remove the trickle charger from the battery. The circuit included a relay connected in series with the A-battery filament circuit. With no filament current, the relay relaxed and the trickle charger outlet was powered from 110-volt line. When the filaments were lighted, their current operated the relay, and its contacts switched the 110- volt line from the trickle charger to the primary of the Power Unit transformer. The B-Power Unit then provided high voltage to the receiver.

Going to socket power for complete receivers, that is, meeting both the B-Power and the A-Power requirements, had to wait for an improvement in vacuum-tube technology. The difficulty came from the effect of using alternating current to heat the filaments in tubes like the type-201A. To conserve battery energy, the filaments in such tubes had been reduced in

size (wire diameter) and in operating temperature so that there was very little excess thermal capacity. Another way of saying this is that the emission from the filament wire would change drastically during alternating-current half cycles, providing more electrons than were useful during the peaks, but starving the tube during the zero crossings. The following segment of this chapter, Model 36, discusses the solution to the amplifier-filament problem.

When the market called for an electric radio, Atwater Kent modified the Model 33 radio and the Model R B-Power Unit. He and many other manufacturers chose the twin-diode thermionic tube as the best way to provide rectification in their power supplies. The type-80 tube was developed specifically for that service. It had a long history of ancestors, the most immediate having been the type-213 double-rectifier tube. Much work had been done on the performance of emitting surfaces to determine and enhance the production of free electrons as a result of heating a filament, the basic concept of thermionic tubes. In the type-213 tube, pure tungsten was used as a directly-heated cathode filament. This material worked satisfactorily insofar as emission was concerned, but ran very hot and radiated more thermal energy than was desirable for receiver applications. The oxide-coated tungsten filament ribbon solved the cathode-heating problem for rectifiers even more effectively than it did for amplifier tubes because of their higher current requirements. (Rectifier current usually exceeds the sum of the amplifier currents in a receiver.)

The type-80 tube was, therefore, the means of choice for Atwater Kent's transition to ac radios. It was designed into the Type-Y Power Supply, No. 9360, which provided the several voltages needed in the ac receiver. The filament voltages (and in the case of the detector, the heater voltage) were taken from extra windings on the power transformer. The three different B voltages for the amplifiers and the detector were taken through the rectifier and filters. Because the plate voltage for the second AF amplifier was raised from about 100 volts, as used in battery sets, to nearly 200 volts, the Type-Y Power Supply included a speaker choke to parallel feed the final plate circuit, thereby isolating the speaker from the dc supply voltage.

The Type-Y Power Supply nicely illustrates the economic principle that Atwater Kent followed throughout his radio production; modify existing products to meet new needs. First he modified the Type-R B-Power Unit to make the Type-Y Power Supply. The external metal container was very similar to the one made for the Type-R B-Power Unit. Two versions of the Type-Y Power Supply were produced, the second a modest improvement over the first. The internal arrangements of all three devices were similar, the main changes being made to accommodate the filament lines. The

other changes were removal of the trickle-charge relay in going from the Type-R B-Power Unit to the type-Power Supply , and moving the terminals from the front to the top in going from early Type-Y Power Supply to the later version.

Electrically, the changes among the three units were developmental rather than drastic. Getting rid of the gas rectifier in the Type-R B-Power Unit meant adding the type-80 filament winding and connections in the Type-Y Power Supply, but the big tubular resistor was retained to provide drops and bleeder action. In the later Type-Y Power Supply the bleeder was eliminated and dropping resistors were installed on the underside of the terminal board that had been moved inside. The internal terminal board and the means of connecting the power cable using 8-32 screws and nuts were retained in subsequent sets through the Model 57, nearly two years later. Another change between the early and late versions of the Type-Y was the elimination of the variable-centering resistor used to return the RF-amplifier currents, on the earlier version, in favor of a fixed center-tapped resistor in the late version and in subsequent ac power packs.

A change which again illustrates the economic principle of modification versus new is exemplified by the on-off switching connection. In the early version of the Type-Y, this wiring was separate from the main cable and terminated in a plug/receptacle that was mounted in the opening formerly used in the Type-R B-Power Unit for the trickle-charger connection. This was partially necessitated by the use of the hole, and partially resulted from insufficient terminals on the output panel. Most probably, it was the consequence of Atwater Kent wanting to retain the Type-R B-Power Unit case. (He might have had a stockroom full since the Type-R B-Power Unit was not the way to go.) On the later version, the hole, the plug, and the receptacle were eliminated and the ac switch-line was added to the horizontal terminal board where it remained as long as separate power containers were used.

In the later version of the Type-Y Power Supply, the filtering system was simplified to remove the double power choke and to enclose the speaker choke with the power choke. The condensers were also enclosed in a single container. Both of these changes simplified the manufacturing of the power supply and consequently reduced its cost. By putting all like elements together, the costs of making the condenser block and choke block were also reduced. Further, the cost to assemble the entire power supply was reduced by eliminating one container and simplifying the associated wiring. Atwater Kent brought together all the factors needed to produce a complete socket-power receiving set. He used Model 33 as the receiver portion, with a redesigned detector. He upgraded the Type-R B-Power

Unit to the Model Y Power Supply requirements by changing to a type-280 high-vacuum rectifier tube and modifying the power transformer. In the next segment, the result, Model 36, will be reviewed.

THE MODEL 36, No. 9390

The use of electricity as a servant in the home to provide safe, convenient illumination was well established at the turn of the century. In the beginning of the twentieth century electrical helpers appeared in many forms; washers, refrigerators, appliances and tools. Socket power for radio was, to the non-technical listener, the employment of another electrical servant, and was consequently strongly demanded. The Atwater Kent Model 36 typifies, for the historian, the means by which developing electrical technology of the twenties fulfilled the new demand of the rapidly expanding radio public.

A fundamental goal of the engineering process is to utilize earlier experience in meeting a new or changed requirement. But for a new requirement, new ideas must be incorporated into the earlier experience if the resulting product is to be new. The cost of an entirely new device is many times higher than for a similar device that utilizes its heritage. This cost can be reckoned in time to design and manufacture, in removing initial flaws (bugs), and in the difficulty of generating user experience. All of these costs can result in a price so high for the new device as to remove it from the market place if a modified product is available. Atwater Kent was acutely aware of the experience-versus-new dynamic. All of his radios were modifications of earlier designs, even at the beginning, when he modified automotive-electrical parts to produce breadboard modules.

Continued growth of the Atwater Kent Manufacturing Company in 1926 demanded major changes in the appearance and the performance of the radios that had, up to then, brought great success to the company. In only five years, radio receivers had progressed from single-tube detectors through regenerators to one-dial tuned radio-frequency receivers. Their sound had changed from the tinny tone of metal horns to the soft voices of magnetic cones. Power for the sets was changing from batteries to line-powered A and B eliminators. Radio was no longer a novelty; it had become an important part of household life.

The market was ready for better radio sets, and new technology made them possible. Progressive manufacturers incorporated the new tubes that operated with ac filament power, the higher-powered audio output triodes, the full wave rectifiers, and the electrodynamic loudspeaker into modified designs that ultimately made the radio set a convenient home appliance. The story of Atwater Kent products during that time gives a

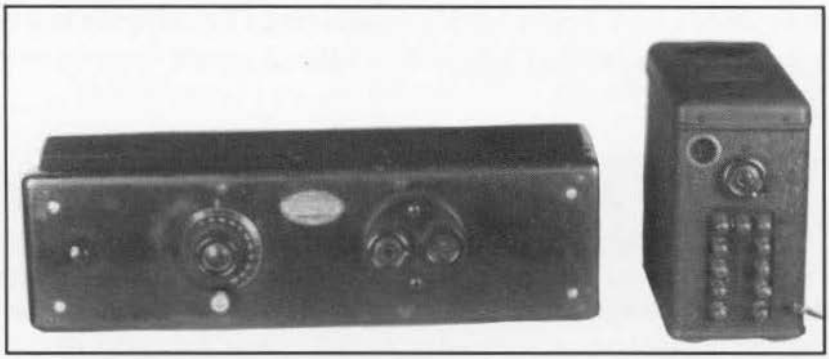
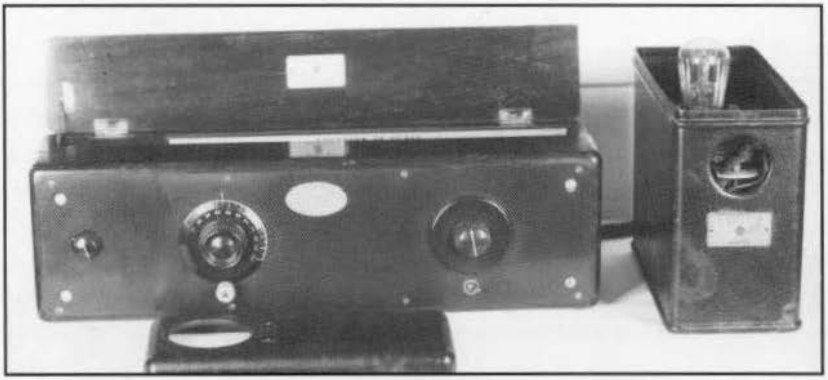


Figure 43. (above) Model 36, Early. Model 33 with the Model-R power supply became Kent's first house-power receiver. Notice the similarities to the earlier equipment. The main difference was the power cable.

Figure 44. (below) Model 36, Late. The radio and power supply were electrically identical to the early version but the power switching and last-stage hum control were improved.



good picture of the problems that all had to solve, and how Kent went about solving them.

For Atwater Kent the electric-radio concept came together in the Model 36, Figures 43 and 44. The underlying design of the signal-handling part of the set had been completed with Model 33, the seven-tube battery receiver that was the top of the line in late 1926. With a slightly modified Model 33, and a power supply derived from the Model R Power Unit, the electric series was born. Model 36 used a new tube, type 226, for its radio and audio amplifiers because the type-201A tube was not satisfactory with ac heating its filament. With the exception of its 1½-volt filament, the type 226 had the same operating characteristics as the type-201A, and consequently required no changes in circuit parameters.

For detector operation, however, the type 226 was not satisfactory. To overcome the limitations of a directly-heated filament, another triode having nearly the same operating characteristics but using a coated-cathode cylinder to emit electrons had been developed. This one, type 227, was free of hum and made an excellent grid-leak detector. Because the type 227 added a cathode element, it was given a five-pin base and therefore required the audio-amplifier base plate to be changed. Only minor changes were made to the mahogany box to accommodate the ac filament tubes and to the cable to bring filament power for them from the power supply.

At about this same time, the middle twenties, another very pertinent radio receiver problem, audio-output power, was being solved. Operating a battery radio that could produce high power was far too expensive for the ordinary home. With the advent of the electric set, however, the demand for audio power could be economically met. A new output tube, the type UX171 (later type 171A) was developed by Westinghouse and made available by RCA for much enhanced receiver performance. It could produce several times as much power output as the type-201A but it used more current, operated at a higher plate voltage and had to be biased.

The Model-R power unit that Atwater Kent had marketed as a B-eliminator had to be redesigned for Model 36. The transformer design and the filters were adequate but the rectifier (Part No. 607, an argon gas tube) was severely limited for increased current applications, especially when operated at a high enough voltage to provide for both the plate and bias requirements of the type-171A audio-output tube. The improvement resulted from the development of high-vacuum, full-wave rectifier tubes by GE and Westinghouse. These included the type 213, the first commercially available full-wave rectifier (also limited for this application), and the type 280, an upgraded type 213, which met the requirements admirably. Model 36 and all but one of the subsequent Atwater Kent receivers included the type-280 rectifier or its octal version, the type 5Z4.

Kent's Model 36 reveals its parents by a simple comparison. The cabinet was nearly identical to Model 33, and only a generation away from Model 20. The radio and audio circuits and their mechanical embodiment were so similar to their immediate predecessor, Model 33, that only detailed comparison reveals the differences. As observed above, the big differences in Model 36, aside from the power supply, were in the filament circuitry and the detector. These changes reflected technical advance; the similarities demonstrated the economic value of experience. Use of the same coils, tuning condensers and ganging arrangements meant that the new set, Model 36, would cost more only because the power supply was an additional module in the set. In the competition of

the market place, the new set was assured a strong position because it changed only where changes were demanded by the public. Its price increase over earlier models was more than compensated for by the reduction in battery cost.

But circuit design did not stand still in Model 36. Comparison of the two versions of Model 36 shows that another problem, volume control, was still being worked on. The circuit of the early version shows that a stepped-impedance was used to couple the plate of the first radio-amplifier tube to the primary of the first interstage transformer. Variation of listening level was accomplished by switching capacitors (in series) whose impedance reduced the primary current in the transformer, thereby reducing the first-stage gain. Although the switched capacitor concept provided volume control, it was not adequate from a production-cost standpoint. The capacitors had to be individually wound and then assembled into a control. A simpler device was a variable resistor, which shunted the plate circuit of the first and second radio amplifiers, thereby giving very effective volume reduction.

Model 36 looked and performed very well, as did the battery version, Model 33. Both sets were marketed in 1927 but about twice as many Model 33s were produced (70,000) as Model 36s. It may be that Model 36 was really a transition set whose function was to permit Atwater Kent to get into the market before the version he wanted to produce, Model 37, was ready. In looking back, the Model 36 was one of the more interesting sets in the Atwater Kent line. Its style marked the end of the battery era and at the same time its use of house-power began the new era that made the radio a modern necessity.

Consoles incorporating Atwater Kent receivers (but not sold by him) were well established by the time Model 36 came along. They had started with Model 10 and were used with Model 20 and the several different sets in the 30s family. With the change from battery to socket power, and with the increasing importance of radio in the home, the console form became even more popular. Still, Atwater Kent did not offer his own consoles for general sale. Another year was to pass before the company would decide to enter that market directly.

MODEL 37, Nos. 9500, 9740, 9700, 9830

In reviewing the few Atwater Kent factory records that still exist, it is clear that 1926 was a busy year for his engineering force. Not only were the Models 33 and 36 brought to market but the next set in the series, Model 37, was also introduced. This receiver, Figure 45, was the first one to incorporate a power supply, together with the radio and audio circuits, in a single enclosure. The fashion of the modern Model 37 in a



Figure 45. *Model 37. This radio ushered in the new wave of prosperity for Kent. It put him in the metal fabricating business and led to his doubling the factory on Wissahickon Avenue.*

living room of the late twenties was a significant change from the appearance of the older mahogany boxes. The metal case left an impression of the benefits of technology, whereas the older wooden boxes were variations of common household containers. In using the steel enclosures Atwater Kent was very much in tune with his times. Doubtless, the 1927 radio buyer concurred that major differences existed between the metal set and earlier models, but for the listener, the overriding feature was the power source; the household electric service. Other features such as increased volume and sensitivity and unit construction added to the appeal of the metal box. Altogether, the metal-box radios were a very big step in radio progress. Many of the collectors, whose efforts are separated by half a century from the era of the metal-box sets, look back at those sets with less than the admiration they deserve.

No evidence has been uncovered to indicate that Atwater Kent did extensive experimental work on the properties of steel. More likely is the idea that he followed the experience of other industries in the fabrication of panels and other shapes, adapting their practices and processes to his application. With Kent's involvement in the use of steel panels, shelves and attachments for the earlier mahogany-box radios, and his negative view of small wooden cabinets, abetted by his strong interest in automobiles, his introduction of the metal enclosure was almost inevitable.

The largest impetus for steel shaping came from the automobile industry. The steel industry, together with the automobile industry, had developed ductile steel and suitable tools to produce complex, stamped shapes. Such parts as fenders and doors were changed from flat, or simply-curved panels, to complex three-dimensional drawn surfaces that not

only had pleasing contours but also provided strength and stiffness to their application. The new automobile styles made everyone aware that steel shaping was a wonderful improvement. An ordinary individual would have been familiar with the changes in car fashions and welcomed the results. Closer to home, the wonders of steel were revealed in new major appliances like the refrigerators and ranges that became the energy-servants of the housewife. With this favorable attitude toward shaped steel, the novel metal radio cabinet of Model 37 conveyed the impression that the world approved the choice. The metal-box receivers stand as powerful evidences of the engineering, manufacturing, and programming arts that brought radio into the very center of our lives like a beneficent whirlwind.

Atwater Kent must have had a very clear picture of the acceptance of the metal-box radio. The sales of Model 35 were abundant evidence that style was selling radios since that set was really a repackaged Model 30. Although Kent advertised one-dial tuning for Model 35, that advance alone was not enough to account for Model 35 selling twice as well as Model 30. The steel box, the reliable circuitry, and the Model Y power supply from Model 36 must have looked like pure gold to the marketing people at the factory. All that was needed was to expand the plant to fabricate Model 37 cabinets in quantity, and that was one of Mr. Kent's specialties. The Atwater Kent manufacturing record shows that the factory was busy, since the difference between making set number 1,000,000 (a Model 35) and making set number 2,000,000 (a Model 40), a year and a half later, was the pair in between, Model 37 and Model 38.

The Model 37 steel cabinet was designed to be relatively easy to fabricate. Three pieces made up the box, with a fourth piece shaped to make the cover. The bottom was a simple flat punching to which the front and back pieces were spot welded. The front was complex but not as difficult to draw as the Model 35 case. It was formed first as a channel about thirty inches long. Then it was re-stamped to form the corners. The rear piece was pressed similarly. During the drawing sequences, the various holes were punched for the dial shaft, the antenna attenuator, the power switch and the rear accesses. Then the front and rear sections were spot-welded together. Next the brackets for securing the chassis were spot-welded inside the front section. Finally, the bottom was welded to the sides to complete the box. The amount of machinery that had to be accumulated and put in place to manufacture the metal-box radios was, to anyone not familiar with metal-forming plants, impressive if not staggering.

The characteristic decoration of Model 37 was the ship nameplate, a coined medallion that was first used on Model 35. It was fastened in the center of a rectangular panel outlined on the cover by stamping during

the fabrication process. The panel was painted gold wrinkle to contrast with the brown-wrinkle finish on the rest of the cabinet. On Model 37 the panel was flat but on later sets the panel was slightly convex. Some of the flat-panel covers were used on the early Model 40 radios, perhaps to zero the stock before the improved (stiffer) covers were produced. The other recognition feature of Model 37 was the dial with its vernier drive. The dial was brown, reading from 0-100 clockwise, and first used on the late Model 10. The vernier was gold-plated and went back even further to the coupled-circuit tuner.

In the introduction of the bathtub style, the removable cover was an integral part of the box assembly. This piece was drawn from a single sheet and stamped with the rectangular-panel outline. A single pass might have performed both operations if the drawing dies also carried contoured faces. The outside edges of the original sheet were then sheared off and the remaining rough edges were squared. A punching operation put the holes in the center for the medallion which, like that on Model 35, pictured a ship. Four holes were punched in the corners for the decorative square-headed rivets. After the top was deburred and cleaned, it was painted. Inside, smooth brown paint was used. Outside, the panel was finished in gold wrinkle and the surrounding area was painted a wrinkle brown that matched the rest of the box.

Altogether, the top was a sophisticated piece that illustrates the quality of steel forming that had been highly developed by the mid-twenties (and which has not been markedly improved since.) The fit between the cover and the main box had to be very close. A few thousandths too small and the cover didn't go on. A few thousandths too large and the cover would be sloppy. Properly shaping and sizing the cover took the highly skilled metal-drawing work that characterized the Atwater Kent factory. While good practice indicates that all the covers produced for a particular model should have been the same size (and the specified dimensions,) and that all the boxes should also have been correct, they weren't. The boxes and covers were made in runs (quantities made in one group, at one time to one set of tolerances.) The covers made for one run of sets did not necessarily fit the boxes of other runs. Present-day collectors know how difficult prying off a good looking cover can get.

The minor electrical changes that Atwater Kent's engineers made to go from Model 35 to Model 37 were very similar to those they made in going from Model 33 to Model 36. They altered the filament circuitry, changed to an input attenuator, and bolted the entire assembly in the new metal radio that became Model 37. Again, the tubes used in Model 37 were type 226, type 227, and type 171 A. In order to integrate the Model 36 power supply (Model Y) in the single cabinet of Model 37, it had to

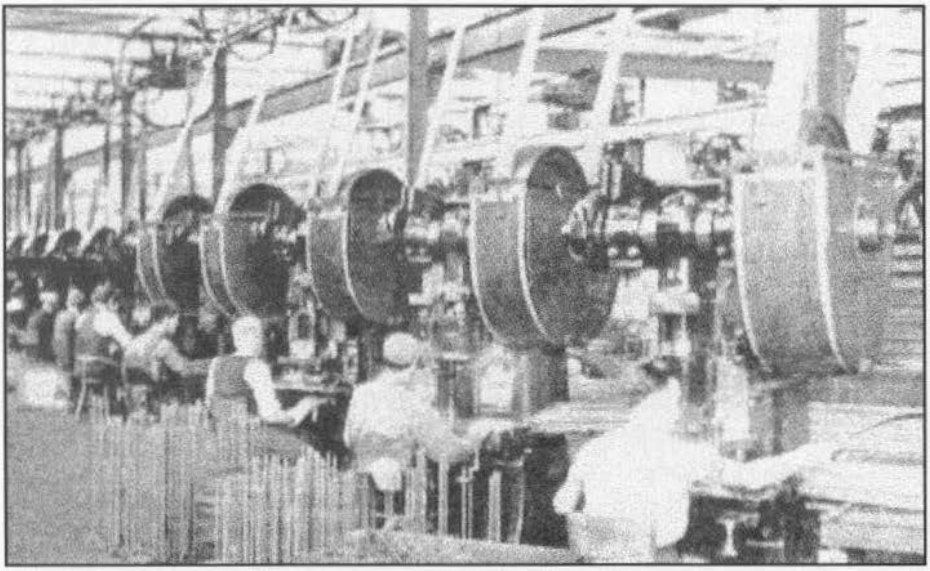


Figure 46. *Factory Presses. Making the cases for the new line required new factory tools. Kent's familiarity with automobile manufacturing made the transition practical.*

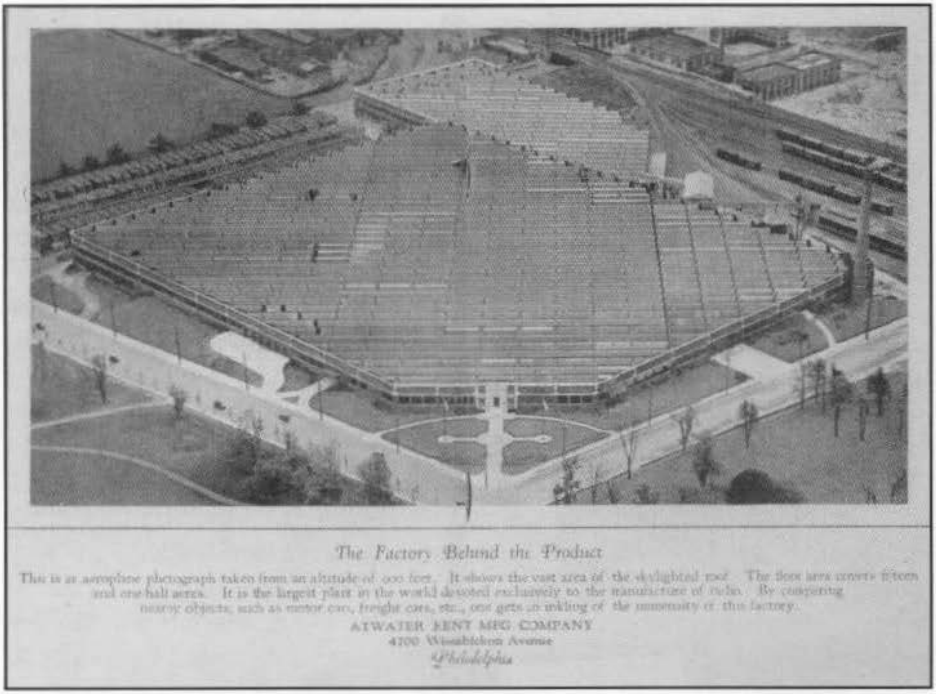


Figure 47. *Early Factory. The first presses were used in this building, but the metal-box sets needed more space. The new building was added for the expansion. See Figure 105, right side.*

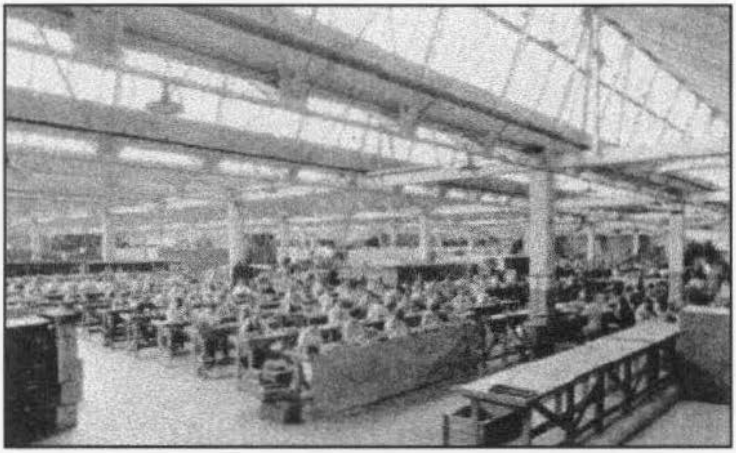


Figure 48. *Assembly Benches. The chassis assembly was light work and could be done at individual work stations. Later the work was done on progressive-assembly production lines.*

be mechanically redesigned, but electrically no changes were necessary. The arrangement of parts, and especially the enclosure, was not usable. A smaller, rectangular sub-case was designed to enclose the transformer, the condensers and the chokes. The connection panel was mounted at the top. To interconnect the signal chassis to the power supply, the cable was redesigned to be shorter and to follow a smooth path between units.

Model 37 has maintained a reputation as a good performer. Over the years, since it first appeared, the main failure has been puncture of the paper-dielectric insulation in the filter condensers. During the active years for the metal-box sets, when customers needed dealer service, repair was made by replacing the complete power supply. Present-day collectors, troubleshooting a failed power supply, occasionally find that the high-voltage winding of the power transformer has also been damaged. This is usually a secondary fault caused by the shorted condenser and an type-80 rectifier tube that unfortunately survived the heavy overload. Sometimes, in a restoration, the type-80 tube is found to be defunct, but that is what saved the transformer. Nevertheless, replacing the condensers is an adventure in working with potting tar.

Model 37 was the first receiver in the metal-box series. Its impact on factory operations and tooling was substantial. The increase in investment in new tooling was based on earlier experience and projected production rates. Operator-fed punches and stampers could reach a rate of 100 units per hour. In a normal work week the output might climb as high as 5000 units, but half that number would be far more realistic. Therefore, to produce the million sets in two years, there would have been four machines

in use for each operation. For the metal boxes alone, as many as seventeen major operations were required so that one would have expected to see 70 or more large presses just to cut and form the steel. Associated with them had to be a fleet of material-handling trucks to bring the raw material, transport between operations and carry away the finished boxes. When the rate was up, the steel-forming room must have been a noisy, exciting place. Figure 46 gives a good idea of how it looked when the metal boxes were being fabricated.

Because the manufacture of the metal boxes was a new series of operations that had to be set up and put into production while the wooden-box sets were still being made, Atwater Kent used all the remaining floor area in the first building at 4700 Wissahickon Avenue, Figure 47. At the same time plans were being made for the next series of radios, the Forties Series. It was clear that more space was needed, so the engineering and contracting for the second building at 5000 Wissahickon Avenue was begun. Figure 105 (page 308). shows both sections of the factory. The original building (4700) is on the left (east) and was, in its own right, the largest radio factory in the world. The new building (5000 Wissahickon Avenue - on the right) doubled the factory size to a total area of 32 acres. Although the new metal boxes required new tools and new factory space, the rapidly growing production rate required a far greater expansion of the assembly space. In the assembly methods used at the Atwater Kent factory during the time of Model 37 and the later metal boxes, each radio was assembled at a work station rather than on an assembly line. Chassis were assembled in one area, wired in another, installed in the cases in still another.

The bench space for all these operations must have been measurable in miles. A view of those benches is presented in Figure 48. Note the roof design that admitted light through nearly vertical windows, separated into rows by the inclined roof panels. Atwater Kent had carefully chosen the direction of the serrated roof so that the overhead windows admitted only north light. As may be seen in the picture of the entire factory, the window direction was almost 45 degrees away from the main walls of the building. At the time of its use, the factory was considered to have been the very acme of modern manufacturing practice

Five versions of Model 37 were produced. The first two were an early and a late configuration that corresponded to the third and fourth versions of Model 35. The difference between them was in the tuning condensers. The earlier sets used 13-plate tuning condensers, the later ones used 17 plates. The radio-frequency coils were changed to correspond with the change in tuning capacitance while maintaining coverage of the broadcast band. The early version was identified by the tube chart pasted

to the front of the power supply (near the top). On the later version, the chart was located on the bottom of the cabinet between the signal chassis and the power supply.

The third version of Model 37 was No. 9700, the console set. It had the same radio chassis and power supply as the second version but did not have a cabinet as it was sold to furniture companies for assembly into console model radios. The fourth and fifth versions were the same radios as the second and third versions but were equipped with power transformers suitable for use on 25-cycle-per-second power systems. The cabinet Model was No. 9740 and the Console set was No. 9830. These two radio sets indicate that Atwater Kent's expected market was national, since many U.S. cities were supplied with 25-cps power in 1926.

MODEL 38, No. 9400

Atwater Kent carried parallel lines of receivers through all the model years of his production. These were the result of customer preferences. The first directly-related example of parallel sets was Model 12 with Model 10, the Radiodyne. In the earlier mahogany-box series, there appeared to have been a six-tube version of Model 20, identified as Model 22. In the later mahogany boxes, Model 32 paralleled Model 30. The parallels continued into the metal-box production where Model 38 accompanied Model 37. Some families were pleased with the standard, highly effective, seven-tube radio that was Atwater Kent's main offering. Others wanted the more expensive, slightly more sensitive, and probably more impressive eight-tube, top-of-the-line receiver, the Model 38, Figure 49.

Model 38 was built from the modified radio and audio circuits in Model 33, added the power supply developed for Model 37, and utilized a cabinet that was about four inches wider than Model 37. The changes in filament and output circuitry that were necessary to use the new alternating-current tubes were the same as those made for Model 37. The other similarities were the dial, the gold vernier and the ship medallion. The tuning dial was not only identical on both sets but was the same as on earlier sets, brown in color and marked from 0-100 by tens in the clockwise direction. Other features that were identical in both radios included the power supply and its cable; the main controls and terminals for the operation of the set; and the construction, finish and decoration of the cabinet.

Model 38 differed from Model 37 in only one important characteristic, the extra radio-amplifier stage in Model 38. Along with the extra tube were the socket and the other elements that made up the tuning arrangement, the belted variable condenser; the coil and the damping resistor. The

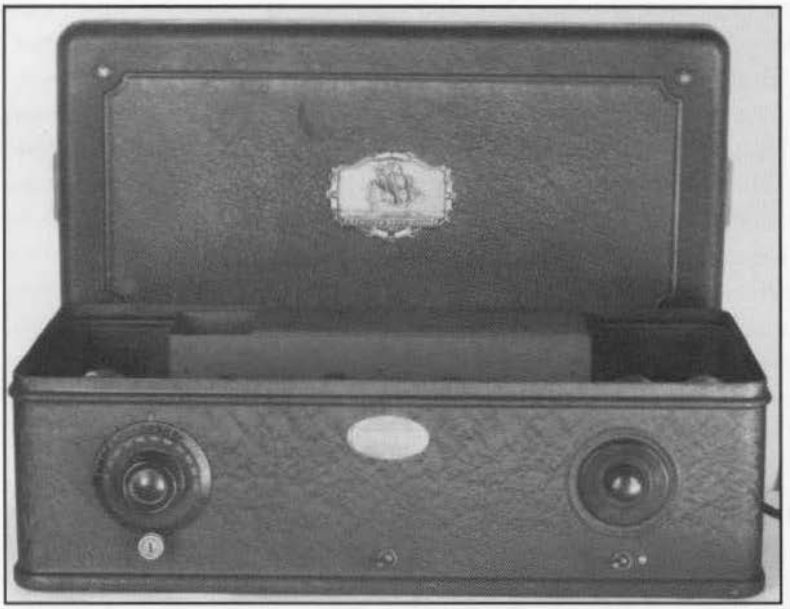


Figure 49. *Model 38. Model 10 and Model 12 were paired as were Model 30 and Model 32. Similarly, Kent supplemented Model 37 with another tube in Model 38.*

extra amplifier stage resulted in the larger box for Model 38, 21 inches wide compared to 17 inches for Model 37. The other dimensions (10 inches deep and 7 inches high) were identical in the two radios. Correspondingly, the covers differed in width.

The fourth radio amplifier provided the extra sensitivity that was needed for use when the listener was remote from high-powered stations and propagation conditions made his reception difficult or non-existent. The second radio amplifier was equipped with a switch that cut off its plate supply during the reception of loud signals. With the extra stage power off, the inter electrode capacitance of the tube and the primary-to-secondary capacitance of the second RF transformer carried the signal from the first stage to the third stage. This feature was introduced in the Atwater Kent line of sets with Model 38.

Another feature introduced with both Models 38 and 37 was the volume control, a variable resistor in the antenna circuit. By reducing the value of resistance shunting the antenna, its efficiency was reduced, and correspondingly, the amount of signal transferred to the grid of the first stage was diminished. The purpose and function of the choke in the antenna circuit was the same as in Models 32 and 35, where it provided a high impedance return for the first grid. For maximum sensitivity, the

volume-control resistor was advanced to its maximum position (the clockwise limit) where the wiper passed off the wire-wound resistance element.

The power supply in Model 38 was identical to that of Model 37 in both electrical circuitry and in mechanical construction. It was also identical in circuitry and performance to the late Model 36 Model Y power unit. The covers on Models 37 and 38 were much flatter than the ones pressed out for the later metal-box radios. They had decorative rivets in the top corners and a ship medallion in the center, the same one that had been used on Model 35. The ship medallion and the rivets were the main identifications of Model 38 and Model 37. These details were discontinued in subsequent sets. While the mechanical details of the metal box sets were still evolving, the circuit had been stabilized and would, with only minor changes, remain constant over the entire Forties Series of sets. Atwater Kent understood very well the concept of maintaining internal details that worked well, while continuing to update the features that pleased his customers.

Chapter 8

THE FORTIES SERIES

MODEL 40, No. 9800

Model 40, No. 9800 followed directly on Model 37. With the immediate success that Atwater Kent enjoyed with Model 37, it must have been easy to decide what to do for the 1928 product line. Manufacturing had only to keep the production lines operating at full speed. Engineering needed only to make minor design changes to minimize costly elements in production, and to dress the appearance of the set enough to assure clear and separate identification in the marketplace. For 1928, the seven-tube standard, Model 37 radio became Model 40. The eight-tube top-of-the-line, Model 38 receiver became Model 45. From the viewpoint of a technical historian, the changes were uninteresting. From the entrepreneurial viewpoint they were very significant, because they were so minor. They were a study in how little, rather than how much, had to be done to make a model change in a seller's market. Model 40 was nearly identical in its electrical circuitry to Model 37. The main difference between the sets was the way in which the power supply was packaged. In Model 40 and subsequent sets, the power-supply enclosure was a single container into which were potted the power transformer, the filter capacitors and chokes, and the choke for the last audio-stage power feed.

A collector looking back at Atwater Kent's metal-box receivers has difficulty evaluating them. Present experience with electronic products and with mechanical devices is not an adequate basis for understanding the milieu of the developers and inventors of early electric radios. Atwater Kent's metal-box receivers illustrate this evaluative dichotomy very well. Present collectors don't see much drama in the appearance of the metal boxes and tend to dismiss them as dull or pedestrian. The evaluation made by the buyers and users of the Atwater Kent radios marketed toward the end of the 1920s offers a very different picture of the metal-box receiver. At that time, the level of customer acceptance for his radio sets was very high. Starting with Model 37 and going only through Model 47, the metal boxes (using triodes for their radio-frequency amplifiers) were produced for only two years, late 1927 through middle 1929. Then,



Figure 50. Model 40. *The market welcomed the metal-box sets so Kent upgraded the Model-37 power supply by sealing it. With this action, he embarked on his rise to become the No. 1 supplier.*

after the screen-grid tube was introduced, the metal-box receivers continued for another model year with the Model 55 and the Sixties series. But in that time several million metal-box receivers were sold, and the entire factory facility at 5000 Wissahickon Avenue, Philadelphia, was built and profitably operated.

Model 40 is pictured in Figure 50. Its top differed in decoration and profile from Model 37, but the body of the case and the lay-out were identical. Model 40 shows the result of production improvement and simplification. With such minor changes it lost none of its appeal to the radio public. Instead, it went forward to become so popular that Atwater Kent celebrated the production of his second million sets by presenting Number Two Million to President Herbert Hoover, Figure 51. Using early 1929 as the date for reaching two million, and early 1927 as the date for reaching one million, an annual production rate of half a million radios seems indicated. Other figures point to even higher rates, e.g., in 1928 when 600,000 sets may have been manufactured. And these were the lowly bathtubs, mostly Model 40!

The product line must have been judged as excellent by the customers of the time. One is certainly impelled to ask why. Did Atwater Kent have only a small segment of a total market which found some other radio lines more attractive? No, he was Number One. Was there something in the contemporary American home furnishing scene that made the metal case attractive? Perhaps so. The twenties saw the beginning of mass production, not so much as an environment highly destructive of human values, but as a source of great respect for American initiative and capability. It was also a means by which the middle class emerged with material wealth and comfort.

The pressed-metal container with its single dial and drum speaker were symbolic of these achievements. Plugged into the electric socket,



Figure 51. *Kent tests Hoover's radio. To keep his name before the public, Kent presented Model 40, Serial 1,000,000, to Herbert Hoover. The sets with serial numbers one higher and one lower are still packed for shipping.*

they spoke of the burgeoning success of the American way. When the metal-box radios were new, transcontinental network broadcasts had just come into the living room, refrigerators were appearing in kitchens, and electricity was providing servants for all families, not just the rich. The depression had not yet revealed the dark side of unfettered material wealth. It may be that in the twenties the metal boxes that seem so ugly today symbolized a beauty that was not intrinsic but was, instead, reflective of that time.

Did the metal-box radio perform especially well? Did it differ in any important way from its predecessors? Electrically, there were two significant improvements that the metal-box sets incorporated, although both were actually introduced before Models 37 and 38. One of these was the paper-cone speaker with its magnetically-driven armature. Atwater Kent could not be considered as the main originator of this loudspeaker design or even a producer of the best examples of its embodiment, but he certainly capitalized on its capability and appeal with the Model-E loud speaker.

The second important development was the socket-power source for filament, plate and bias voltages. Underlying the use of socket power were the new vacuum tubes that had filaments and cathodes that could be heated using alternating current and plate ratings that could take advantage of the increase in available B voltages. Socket power and the magnetic speaker meant more and better sound, more amplification per stage and reduced operating costs. For those manufacturers who built high quality into their radios, the enhanced reliability and dependability in the customer's home meant repeat business. The metal-box radios, from the first Model 37 up through Model 45, did not offer dramatic increases in sensitivity and selectivity over the best of the earlier sets that utilized similar circuits, but they were far more docile and dependable.

The changes in appearance offered by Model 40 were a new cover that was slightly convex in cross-section, and a new decorative medallion. The new decoration was hexageonal in outline and art-deco in its look. The traditional ship was replaced by a figure that spoke of the new progressive world. If a customer looked inside he would have seen no changes to the signal circuitry, although the antenna potentiometer was a little different, but he would have seen a new power supply. Its enclosure had been changed from a folded box to a drawn enclosure and cover, not so much to provide customer appeal, but to reduce production costs. Altogether, the changes were characteristic of a continuing product, not a new one.

A review of the entire product line introduced for the 1928 selling season emphatically shows that Atwater Kent was not satisfied to merely replace the successful Models 37 and 38. Clearly he intended to expand

his market by extending his total line of sets while limiting the design costs. One segment of the market that needed a better set was made up of homes on the peripheries of the alternating-current, power-distribution networks. The other segment was the large market served by direct-current distribution systems. The design of Model 40 was modified slightly to solve these two house-power problems. Model 41 was produced for the homes on dc mains.

The other large market was made up of homes powered by alternating-current generating systems operated at 25 Hz. The stations at Niagara Falls produced prodigious amounts of this power, and Atwater Kent's designs were adequate for 25-Hz service except for the power transformer. He altered Models 40, 42, and 44 to meet the needs of the 25-Hz market by substituting transformers having a higher primary inductance and by adding filtering. These sets were identified with the suffix letter "F." Model 40F was part No. 9960.

MODEL 41, No. 9910

Because the electricity delivered to homes in today's world (the nineties) is by means of alternating current, most collectors do not think much about direct-current distribution and its genesis. It is easy to forget, if we ever really knew, that the first distribution of electricity to homes was the Edison system in September, 1882. Edison and the proponents of alternating-current distribution system engaged themselves in protracted arguments about which was the better way to generate and distribute electricity. Edison championed direct-current distribution, with the result that the residents of many cities could not benefit directly from the greatly improved ac radios that were the thrust of the late twenties.

Atwater Kent saw the dc market as very profitable and easy to penetrate because Model 37 had already solved two-thirds of the problem; the signal chassis and the cabinet. It was therefore a simple matter to modify the filament circuits and add a direct-current filter for the main power. Atwater Kent produced Model 41, Part No. 9910, a radio for direct-current distribution systems that was contemporary with his latest ac designs and styled identically with the Model 40. It was introduced late in 1928 for the 1929 model year. Introduction of the Model 41 dc set gave a lot of people who lived in localities served by dc power systems the opportunity to take advantage of the superior performance of the metal-box electric sets. They were able to leap over the three-dial battery sets that had made broadcasting so popular in the home during the middle twenties.

Using only a direct-current power source imposed limitations. The available plate voltage could be no higher than 90 volts after filtering. While the radio-frequency amplifier, the detector and first stage audio-amplifier parameters could remain relatively unchanged with reduced plate voltage, the output audio stage used in the ac version was unsatisfactory for the dc set. By going to a "double audio amplifier," which was effectively a Class A push-pull stage, the power amplification and impedance matching could be made nearly the same for Model 41 as for Model 40, and the Model E speaker could be driven to its useful limits on strong stations.

In order to incorporate the second output amplifier tube, which was a second type 71A, a shelf was added to the right end of the power supply. This was attached and electrically wired like the rectifier-tube shelf used in Model 40, but unnecessary in Model 41. The other major limitation was the difficulty of paralleling filaments. The change was to use five-volt tubes and to put all the filaments in series. The type-26 tubes used as amplifiers in the ac sets from Model 36 on were not usable in the dc sets because of their high filament current, one ampere, and low filament voltage, 1½ volts. They were exactly opposite what was needed. type-201A tubes could have been used, but the type 112A was a little better suited to the application. While its amplification factor was nearly identical, 8.5 *vs.* 8 for the type 201A, its mutual transconductance was more than double, 1800 vs. 800. This meant that the required amount of radio-frequency amplification was maintained with the same RF transformers but with the lower plate voltage, and at the same time the filament current was held to about 1/4 A.

In the circuit for the first radio-amplifier stage, a plate resistor of 5000 ohms was inserted in series with the plate and the primary of the first inter stage transformer. The author suspects the resistor was added to reduce the overall radio-frequency amplification of the sets because of a tendency of the amplifiers to regenerate. With only the change from type-26 tubes in the Model 40 to the 112A tubes in the Model 41, the set may have been marginally unstable under the conditions of high line voltage and above-specification amplifier tubes. Reducing the overall gain would have been a partial fix, but reducing stage gain inside the regenerative loop was the better way to assure stability.

Three versions of the dc power supply were used with Model 41. The differences among these versions were related only to the way the radio-frequency chokes, used to isolate the radio circuits from the power line, were wired into the primary power circuit. In the first version, none of the terminals on the connection board was used for the choke; the connections were made internally before the tar was poured. In the second version, both ends of Choke Number Two were brought up to the board along with one terminal of the Number One Choke. In the third version, all four choke leads come up to the terminal board.

Model 41 provided very satisfactory listening for the radio audience of 1929, partly because the set was used generally by city listeners. The capability of the set to select stations was the same as the other receivers in the three-tuner series, but the sensitivity was a little lower for those who wanted full loudspeaker volume. Few present-day collectors have gotten their Model 41 receivers working, usually because of the daunting task of providing an adequate direct-current source. They do perform well, however, when they are tracked and adjusted. The author's set needed some trouble-shooting and repair before the performance could be accurately evaluated, but the first trials indicated results approximately equal to Model 40. Model 41 did its part in keeping Atwater Kent in the competition of the late twenties.

MODEL 42, No. 9850

Atwater Kent's Model 42 receiver was specialized from the more basic set, the Model 40, by the addition of a regulating resistor in the primary circuit of its power transformer. The need for regulation was caused by the very large variation of the line-voltage in some of the alternating-current distribution systems in the twenties. The problem was worse at the fringes of a power system where both short and long-term load variation was beyond the immediate capability of he newer power companies to correct. The nominal line voltage was 110 volts, with 5 volts of nominal expected variation. If the 110-volt line dropped to 95 volts, radios were subject to failure because the tube filaments cooled too much for satisfactory emission. In Model 42, the power transformer was designed to operate with a primary voltage of 70 volts. The series regulating resistance took up the difference, whether it was 40 volts, based on the normal line voltage, or a lower value, e.g., 20 volts, based on a line voltage of 90 volts.

The second change of Model 42 from Model 40 was in appearance of the metal box. The plain case of Model 42 was dressed by adding indents at the front corners to give the impression of columns. Four ball-shaped feet were fastened at the bottom of the case to raise the radio about an inch above the table top. The dial color was changed from brown to black with white markings every 20 divisions. The volume-control unit was also changed to black and the gold vernier knob was changed to knurled black Bakelite. Model 42 is easily recognized by the feet, the black dial with the black vernier and the corner indentations. In the same way that Model 40 was equipped for 25 Hz operation, Model 42 was similarly altered for that service. Model 42F and Part Number 9970 were assigned to that set. Like Model 40F, the change was in the power transformer and the filters.

MODEL 43, No. 9870

At about the time that Atwater Kent brought out his metal-box radios a major development in producing sound from an electrical source was made available to radio manufacturers. This was the practical embodiment of the electro-dynamic loudspeaker. Where before the sound was produced by the motion of a magnetic armature pinned to a paper cone, the new loudspeaker used a low-impedance coil suspended directly in a radial magnetic field. The magnetic field produced by voice-coil current reacted against the fixed field in the air-gap and forced the attached paper cone to move in accordance with the audio current. The amount of acoustic volume that the electro-dynamic loudspeaker could produce was many times larger than that of the moving-armature speaker. The electro-dynamic loudspeaker handled more audio power but it also took more power to operate. Its fixed field was produced by direct current flowing through a large many-turn winding.

To take advantage of this new loudspeaker, Atwater Kent modified his very successful Model 40 to make Model 43, No. 9870. He changed the audio-output stage from a single ended type-271A tube to a push-pull pair of type-112A tubes. This required a new inter stage input transformer and the addition of an output transformer that replaced the output choke that had been used in previous electric sets to supply plate voltage to the audio amplifier. The purpose of the output transformer was to change the low impedance of the loudspeaker voice coil to the high-load impedance required by the output tubes.

Why did Kent use type-112A tubes in the double amplifier of the Model 43 receiver? He had experience with type-71A tubes in earlier sets and they were better for his application. Further, in the next variation of the eight-tube metal box series, Model 46, he did go to type-71A tubes for the double amplifier. One explanation is that the power supply for Model 43 was almost the same as the one in Model 42. Both used the regulating resistor and had the same power transformer. A large increase in primary power would have required a redesign. Kent attached a second shelf to the power supply to carry the second output tube but that did not require redesign. The two type-112A tubes drew about the same (or a little less) current than the single type 71A in Model 42. This meant that Model 43 was put out with nearly no change in engineering and manufacturing, another example of meeting new needs with existing technology.

When this explanation is examined, the Part Numbers bear out the story. Model 42 was No. 9850 and Model 43 was No. 9870. The new loudspeaker was No. 9890. The two sets went through the design process together, one to compensate for marginal input power and the other to

utilize the new speaker. Four more features tend to verify the explanation. Both radios had the new black dial with its black vernier and the black volume control. They also shared the ball-shaped feet and the indented columnar corners. The fourth feature was the lid decoration. Both Model 42 and Model 43 had the art-noveau figure on their lids. Model 40 and Model 41 used the harsher art-deco hexagon.

From the outside, the two sets could not be easily separated. Model 43 seems to have been a transition between the best of the early seven-tube metal-box sets and a new genre, the eight-tube, higher-power audio-output set.

MODEL 44, No. 9900

Model 44 was the electric, metal-box radio that continued the marketing approach that Atwater Kent had started with Models 10 and 12. Model 42 was designed with seven tubes, three RF amplifiers, a detector, two audio amplifiers and a rectifier. By adding another RF amplifier Atwater Kent produced Model 44. The eight-tube set provided excellent reception for listeners whose signal level was marginal. The power supply for Model 44 was identical to Model 42, including the regulating resistor. Both Model 44 and Model 42 were designed for those listeners whose electrical systems were subject to excessive voltage variations, and therefore the circuit incorporated the regulating resistor.

The design of the radio part of Model 44 came almost directly from Model 38. The only difference was in the way the local-distance switch was used to change the amplification of the RF section. In Model 44 the switch permitted the listener to reduce the gain by changing a tap on the primary of the second RF transformer. On Model 38 the gain was changed by switching off the second stage.

Model 44 used the single type-71A tube to provide output power to a Model-E loudspeaker. The plate voltage of the output tube was fed through an audio choke in the power supply, and a blocking condenser was connected in series with the loudspeaker to avoid demagnetizing the motor with the high current in the output amplifier. This design had been used in all the prior electric sets except Model 43.

The appearance features of Model 44 were similar to Model 42. The black dial, vernier and volume control were the same. The case and the lid derived from Model 38 and were wider to accommodate the extra RF amplifier, but the corners of the case were indented as with Model 42. The nameplate fastened to the top of the lid was the same art-noveau figure that was used on Model 42. The big difference between Model 44 and the previous metal-box radios was the gold-plated, oval Atwater Kent medallion placed in the center of the front panel.



Figure 52. *Model 44 in Desk. Kent sold his radios through furniture makers. The set in this desk is complete in its metal box with the speaker mounted in the section above.*

Atwater Kent had not started to produce console radios at the time of the first metal-box sets, but he made his radios available to furniture makers who incorporated them in their own offerings. Model 44 was popular as a desk. The entire metal box was installed in an enclosed shelf that had cutouts in its front panel for the dial, volume control, switch and gold medallion. Figure 52 shows such a desk. The loudspeaker was a Model E-2 that was equipped with lugs for fastening it to the desk baffle. The desk was closed by folding the writing shelf up over the radio, and the shelf was equipped with a lock for securing the contents of the body of the desk.

MODEL 45 No. 9880

Model 45, No. 9880 (and Model 44) marked the end of the first series of metal-box receivers. They went from Model 37 with three RF stages to Model 45 with four stages but shared their other features, particularly the single-ended output suitable for the Model E magnetic speaker. A

brief review of the factory development that took place over the time of these receivers tells much about the largest manufacturer of radio sets.

At the Atwater Kent factory in Philadelphia, metal-box set production had expanded rapidly from its beginning in late 1926. It began in the building at 4700 Wissahickon Avenue with the first electric set, Model 36 and the first metal set, Model 35. That building had been constructed for Atwater Kent's first major expansion in 1923 when he realized that the facilities on Stenton Avenue were inadequate for his expected business. At that time he planned a new building that would be the most modern radio manufacturing facility in the world. The design of the building called for a single-floor structure covering nearly 15 acres, nearly 600 feet along Wissahickon Avenue and nearly 1200 feet along Abbottsford Road. The main feature of the building was its saw-tooth roof, a series of nearly vertical windows separated by ramps of roofing about 20 feet from window to window. The windows were oriented to provide north light on the factory floor and were consequently nearly diagonal to the building walls. The roof structure; including the windows, their separating ramps and the bridging joists were designed to leave about 20 feet of free height above the floor. The entire roof was supported on columns spaced 20 feet apart in both directions to provide maximum flexibility in the use of the factory floor.

To expand production from the mahogany box sets, some very large presses that were necessary for shaping metal boxes had to be installed. Presses big enough to shape the Model 35 enclosure together with their necessary support functions; stock handling, intermediate forming and shaping, pickling and painting, finished enclosure storage, had been installed and operated in the first building at No. 4700. Their use taught the factory how much space would be required for the next generation of radio production. There was not nearly enough space in the first building for all the planned production of metal-box radios. Therefore, installing new presses in the first building would not have been a good manufacturing decision.

The much better idea was to divide the manufacturing of metal-box radios into two parts. One part could be the radio chassis and its assembly. The after part could be the metal cabinet. For the planners of the new facilities, the assembly of all the radio chassis for the metal-box radios from Model 37 through Model 47 would be very similar to operations that had been going on in the first building for nearly three years. The existing assembly operations would have to be expanded, but with the termination of the manufacture of mahogany box radios, additional assembly lines could be set up in the vacated space.

When the first building was put into service it became clear that it was extremely well suited to its purpose. It served as a pointer to further

expansion if that were to come about. The very successful business that was the story of the mahogany-box radios and the plan to go to metal cabinets was just such a pointer to further expansion, The second building was started next to the first. It was about the same size, with the same dimensions and roof design. Therefore the planners could put the new metal shaping and finishing operations in the second factory building at 5000 Wissahickon Ave. when it became available in 1927.

By the time Model 45 was in production, the first building did chassis assembly and testing, built loudspeakers, and manufactured remnant mahogany box radios. The first building was also the location of the engineering laboratories, and all the business functions, including management, sales, accounting and service. The new building was used for the metal forming and painting, final assembly, final test, packing and shipping of the metal box sets.

Model 45 was the last radio with a magnetic speaker output of the 40 series. It was part of the 1928 model year although it missed the 1928 holiday-selling season. The set was an eight-tube radio that was the immediate successor to Model 38. It bore the same relation to model 40 as Model 38 did to Model 37, the addition of an RF amplifier. The Model number, suggests that the set was late. Its part number indicates that it was timely. It was No. 9880, which was assigned before those of Models 43 and 44. In Atwater Kent's market planning, Model 45 was conceived as the set to pick up the high end of the next year's market for people who were not ready for the more expensive double-output-stage receivers. It was nearly identical to Model 44, but did not have the power-supply regulator. Model 45 was the direct replacement for Model 38 and went with Model 40 (upscale but no regulator) for those customers who wanted the more expensive receiver. Model 44 sold well in the previous year's high-end market, so bringing out Model 45 was a very profitable way to continue the line.

Model 45, when it was released, was one of the first radios in the Atwater Kent line to be finished in the glossy near-black finish. Model 45 was part of the next year's line, replacing Model 44 with the new took of modern dress that supplemented the crinkle brown which was standard in the 1927 series of sets. Perhaps the lid on Model 45 added an attractive highlight in the living room. It could be obtained with either a red or a green inset panel in the outlined part of the top. In the colored panel the Model 45 displayed the art noveau nameplate that identified the other late sets in the Forties Series.

MODEL 46, No. 14100

Model year 1929 carried the line of Atwater Kent radios forward by producing more receivers with the double-output stage and making them

more attractive to the next year listeners. Model 46 was the main product in the line. The design of the set had started with Model 37 two years before and had been improved to be Model 43 the following year. The next upgrade changed the double-output tubes of Model 43 from type 112A to type 171A. With a good station signal, those tubes produced a little more than a watt of sound power from the set when it was used to drive the Model F2 electromagnetic loudspeaker. This was enough to impress a listener with the capability of Model 46.

The appearance of the new line of receivers was changed by using different paint on the same metal boxes. Model 46 was finished with a gloss finish in very deep-purple brown, almost black, gloss paint. The lid was offered with two colors on the inset panel. One was a bright red and the other a moderate green. The lid was black with a gold separation along the ridge to set off the panel color. For all sets the gold art-noveau nameplate was affixed in the center of the lid. Model 46 was also made with the older wrinkle-brown finish and the gold panel in the lid. The ball feet, black dial and the indented corners from the older metal box sets were retained in Model 46.

The extra power required by the change in output tubes required a redesign of the power supply for Model 46. The basic design, with the right-hand shelf carrying the second-audio output tube, did not change. The power transformer was enlarged to handle the extra load and the filters were changed to accommodate the loudspeaker field. The size of the power-supply container was increased by from 8½ to 10 inches in length and made about one-half inch wider to 3¾ inches. The space between the power supply and the RF coils was reduced. Its effect was to alter the inter stage and wiring capacity. The effect was tuned out in the adjustment and alignment of the radio during production.

MODEL 47, No. 14500

Model 47 was the last of the Atwater Kent metal-box receivers that used triode tubes as RF amplifiers. It was a fitting end to the first series of Kent's electric receivers with its nine tubes, four RF amplifiers, a detector, three AF amplifiers and a rectifier. Aside from the primary regulator, which was no longer necessary to cope with poor power lines, Model 47 embodied the best of Kent's design, manufacturing and performance achievements. It combined top quality, sensitivity, selectivity, power and tone in a fashionable enhancement for an American living room.

The radio was available in several forms. The metal cabinet could be purchased in brown crinkle with a gold panel in the lid, or in a nearly black glossy cabinet with a lid having a red or a green panel. The color

choices were very much like those for Model 45, but the radios were very different, particularly when the loudspeakers were considered. Model 47 used the new Type-F electro-dynamic loudspeaker to handle its high output power. Model 45 used the Type-E free-edge cone, magnetic speaker.

The cabinet of Model 47 was similar to earlier cabinets, having the indented, columnar corners and the ball feet. It was also available in consoles made by other manufacturers, sometimes enclosed and in other cases placed on a metal stand with a shelf underneath for the speaker. Atwater Kent radios were so popular that furniture makers and specialty houses were quick to put them in attractive household devices.

In going to Model 47 the factory made nearly no changes beyond a few new tools to hold in-process assemblies. The cabinet was from Model 44. The circuit was from a blending of the Model 44 RF unit with the Model 46 detector and AF amplifier. The power supply was directly from Model 46. The testing and the instruction book were novel, but the shipping box was the same as earlier units with new exterior markings. Altogether Model 47 must have been a high-profit radio for the Company.

MODEL 48, No. 9840 — MODEL 49, No. 9860

Models 48 and 49 were two very interesting radios in the Atwater Kent product line, for several reasons. One reason is that they were almost identical to Models 30 and 33. The primary difference was the color of the front panels. Models 48 and 49 were released with gold wrinkle-painted front panels. The nameplate on the underside of the lid identified the set with the proper model number and the unique serial number. There were two different Model 48 nameplates, each different from the earlier Model 30. There was only one Model 49 nameplate and it, too, was different from that of Model 33.

The next interesting reason is that these nearly identical battery radios appeared two years later than the radios they replaced. They came out after the advent and successful sales of the electric radios in the Forties Series. Looking back on their appearance in the radio market, they were a commentary on the development of power systems in the United States. Although in cities house-power eliminated the need for battery radios, much of the country was rural and isolated. Commercial-power systems for those families and homes were still years away. There were enough potential listeners who had to use battery radios to make an attractive market for radio manufacturers. Kent recognized the opportunity and manufactured a new run of his successful Model 30 and Model 33 radios. To give them appeal, he dressed them with a new panel and gave them

new Model numbers. Kent was not alone in going after this market, but he was more fortunate than some because his earlier sets had been very popular, worked well and were still viable.

The third interesting point is consideration of what Atwater Kent had to do to get into the market. In the broad sense he had to do nothing. In a narrower frame, he had to find the old drawings and specifications for purchasing and manufacturing, and to allocate space in the factory to set up the old tools and facilities to produce and test the new models. With metal-box fabrication in the new, second building, and producing chassis and power supplies in the first building, it must have been easy to raise the pace to assemble Models 48 and 49 in the same location and with the same fixtures that he had used for Models 30 and 33. This opportunity must have had the look of a very high return for a very low investment.

The foregoing consideration has a flavor of Kent going out to buy new parts to build the new sets. Detailed review of the radios themselves tells a different story. There were two versions of Model 48. One was identical to the third version of Model 30, the one with the old condensers, the pin clips for the tubes, and the larger case. The second set had bayonet sockets, as did the first version of Model 30, but was assembled in the larger case. The nameplates in the two were different, but both carried the Model 48 identification. The set with bayonet sockets also had pot-metal pulleys. The idea that Atwater Kent had a stockroom full of version 1 and version 2 Model 30 radios without cases suggests that Kent simply assembled these units in new cases and labeled them as Model 48. To verify this idea the author disassembled two Model 48 radios.

In working with the first Model 48, a chassis with the bayonet sockets, it would have been easy to conclude that the unit was really a Model 30 that had been used to replace a defunct Model 48 chassis. That could have happened at some time after the original Model 48 was taken out of service. The problem with that explanation is the vernier knob. It was the same as the knobs on the other Model 48 and on two Model 49s. The knob was the same size, shape and finish as on Models 44, 45, 46 and 47 but was brown instead of black. It was also not the gold vernier knob that was standard on all Model 30 sets. The cloth tag on the power cord that identified the leads on both a Model 48 and a Model 49 was dated 1926. This came from the earlier production run.

The author concludes that both of his Model 48 radios were as shipped by the factory and that they were originally Model 30s that had been displaced by Model 30A. Several of the Open Sets in the Ten Series show that Kent was quite successful in using up his older model parts and assemblies. Model 48 seems to be another example. Not all Model

48 radios had gold panels. Perhaps the first ones were over-painted from the brown of Model 30. Later sets were plain brown, indicating acceptance by Kent's customers without a need for the extra dressing.

Model 49 also came in two versions, the gold-painted panel and a plain brown panel. Both sets had the same style nameplates, differing only in the serial numbers. Both sets were identical to Model 33 except for the vernier knob. Kent made some Model 33 radios into Model 36s and some into Model 48s. It seems that he planned for a larger run of Model 33 than he was able to sell, perhaps because of the impact of the electric set on his potential customers. Since he could not have anticipated Model 49, the rural market appears to again have been his good fortune.

Chapter 9

THE UNIQUE MODEL 50 — NO. 8500

Among the radios that characterize the Atwater Kent line, one was so different that it might be called unique. The radio was Model 50, Part No. 8500. It was a battery radio related to Model 30. It had a steel panel painted with Kent's brown-wrinkle finish and it was encased in the mahogany cabinet that was the hallmark of Kent's battery receivers. Model 50 was not a high production model, perhaps because it was to be a top-of-the-line radio, but more likely because it was introduced too late for the market. Model 50 was based on circuitry whose design was beyond anything that came before or after its release.

Model 50 differed from the sets in the Thirties Series by having separate station-selection circuits that did not include RF amplifiers. Amplification of the tuned-signal (the selected station) was done by the four broad-band RF amplifiers that followed the tuning process. The grid-leak detector and the two audio amplifiers were the same as those in Models 30 and 33. The Model 50 radio was contained in a cabinet 21 inches wide, 14 inches deep (including the knobs) and 8 inches high. It was as high as Model 20, as wide as Model 33 and twice as deep as Model 30. Figure 53 shows the Model 50 with its lids open. Model 50 was dramatic in appearance, especially when its two lids were up. A purchaser, who wished to impress his technical friends with the latest advances in radio engineering, had only to open his Model 50.

Inside the mahogany cabinet was a brown-painted aluminum shielded box. Inside this box three smaller shielded boxes were mounted. On the front right was one for the first and second RF amplifiers, a second box at the right rear contained RF amplifiers numbers three and four with the detector, and the third box, in the front left, was the tuning compartment. This last box was tightly closed with a screwed down cover. Inside were the three tuned RF coils. However, the tuning condensers were outside the tuning box, between the front panel of the tuning box and the inside front of the shielded main box. The audio amplifiers, not separately shielded, were contained behind the tuning box in the main shielded box.

The concept of providing frequency discrimination (tuning) before any signal amplification has some advantage, mainly the reduction of the



Figure 53. *Model 50. The extra depth of this set gives space for the tuning compartment and the separate wide amplifiers. This design was an expensive dead end for Kent.*

receiver-noise figure. For receivers operated at the extreme limits of signal accessibility, this is significant. For receivers providing broadcast-band listeners with good signals, the advantage of Model 50 over Model 33 would not have been discernible. Model 50 had numerous disadvantages. Perhaps the first was alignment of the RF compartment in the factory. The spacing and orientation of the RF coils controlled the filtering effectiveness (discrimination) of the set. The relationship of the coils to the box and to each other was adjusted by bending the stiff wires that formed the coil supports. This took a specially trained technician. If that relationship had to be adjusted in the field, for a customer, the serviceman was probably lost. There was no help for him in the service manual.

The second major disadvantage of the Model 50 was the RF amplification. The four stages were expected to amplify the entire broadcast band uniformly. The high-frequency end of the band was subject to the random effects of replacement tube capacity without the means of adjusting high-frequency compensation. That this was a problem can be inferred from part of a sentence in the service manual referring to the inter stage transformers "being of a special air-core design." Models 5 and 7 had this trouble and never solved it. (Radar receivers in WW II went to stagger tuning to get around the narrowed pass band.) Model 50 appears to have been a strong effort to produce a single-dial, battery radio that had strong aesthetic appeal, was a good performer and fitted Atwater Kent's manufacturing and sales capabilities. Unlike Model 47 and 48, Model 50 did not build success on earlier established successes.

Chapter 10

KENT'S FIRST CONSOLES

MODELS 51, 52, 53, 57, and 58

Up to 1929 Atwater Kent had produced only table model radios. Since the Tens-Series, furniture manufacturers such as Pooley had installed Kent's radios in many different styles of furniture, desks, consoles, low-boys, etc. When the metal-box receivers came along they were so popular that other furniture makers were reaping the benefits of using Kent's name and his radios. Kent had resisted going into the furniture business—should this view be changed? Was there something that he should have been doing to reap some of the benefits for himself? Good marketing people used this question as a mantra.

One answer was to put the successful electric sets in small consoles that would serve as chairside or occasional tables, as well as sources of radio entertainment. The cabinet contained the loudspeaker so the set was complete in itself. The convenience and completeness were appealing sales points to go with the fascination of the public with steel cabinets. Producing the new sets did not involve any circuit redesign, and did not even call for any chassis modification. The main consequence to manufacturing of the new design was the cost of new dies and stamping out new panels of steel to form the cabinets.

Atwater Kent brought out five small console sets, four for 60-Hertz house power and one for use on direct-current mains. The first of the ac sets was Model 52, No. 9930, Figure 54. This little radio console was 30 inches high, with the dials and knobs placed on the front about five inches below the top. The first Model 52 consoles were supplied with curved front legs and a pendant decoration at the bottom surface of the case. A later version had straight legs, both front and back, and did not have the decoration. The cabinet was finished in brown-crinkle paint and had a gold-painted cover edged with brown. The radio chassis of Model 52 was nearly identical to that used in Model 42, with a modified loudspeaker mounted in the space under the internal shelf. The loudspeaker was a Model E surrounded by a flange instead of the drum.

A grille made of woven-metal wires, painted gold, was used to dress the opening in the console where the loudspeaker was mounted. An identical

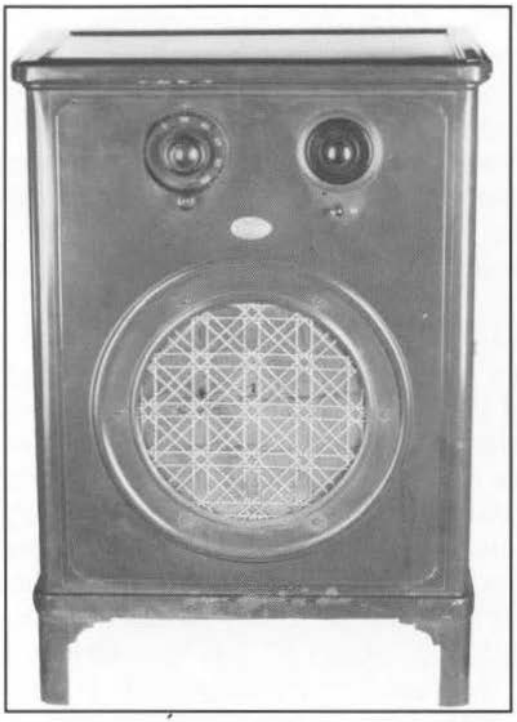


Figure 54. *Model 52. To open up the market for consoles, Kent introduced this style. It was a Model 40 with an included speaker. Most of today's collectors don't appreciate its original appeal.*

grille was mounted on the back of the console. Above the rear grille Atwater Kent placed a ship medallion, first used on Model 35 to dress that side. When the Model 52 was placed next to an upholstered armchair, the back would have been part of the room decor. The medallion and the grille would have fitted nicely with the concept of a modern metal radio bringing the world into the living room. The controls on the front of the radio would have been very convenient to operate, since they were several inches above the curve of the upholstery.

Model 51, No. 9990 was nearly identical in size and finish to Model 52. The differences were in the radio chassis and power supply, taken directly from Model 41, the dc set. In producing Model 51, the factory did not have many new elements to make. The entire console was the same as Model 52. The chassis and power supply was the same as Model 41 except for the nameplate and the antenna leads. The set was easy to produce but, unfortunately, the market was small. For collectors, this model is rare.

The second ac console radio was Model 53. No.13100. It was 26 inches high (four inches lower than Model 52,) had straight legs and was finished in glossy near-black paint. The cover for Model 53 was available with a green panel, edged in black, or with a red panel similarly trimmed. Model 53 was fitted with the same radio chassis that was used in Model 43. Model 53's loudspeaker was Model F2-C. It was the same

as the loudspeaker for Model 43 but it did not use the separate enclosure, instead being mounted in the console. The loudspeaker grille was made of woven-metal wires, painted gold. The rear of Model 53 had seven holes arranged in a hex pattern to permit sound to pass through. Unlike Model 52, the smaller console was for use as an occasional table rather than as a chair side. Its dials were too low and the rear was not suitably decorated for exposure in a living room. Model 53 was also available in a forest-green finish with a gold pinstripe and the gold, front loudspeaker grille.

The other two consoles were Model 56, No. 13900 and Model 57, No. 14000. Both of these radios were equipped with the chassis made for Model 40, the one designed for service on well-regulated ac lines. Neither set had a voltage regulator. Both consoles used the modified Model-E loudspeaker, but neither had the gold, wire mesh grille. Instead they had the bare pattern of seven holes arranged in a hex on both the front and the back. Both sets were painted the near-black color that was used on Model 45 and subsequent sets, including Model 53 but they did not have the green or red panels in their lids. Model 56 was 26 inches high and resembled a plain Model 53. Model 57 was very similar to Model 52 in its size, 30 inches high, but it was much plainer. It would not have been an attractive chairside unless it was placed between the chair and the wall. Altogether these two radios were less expensive versions of the first-described consoles. From the part-number assignments, they all appear to have been put on the market at the same time, late 1928 and early 1929.

Chapter 11

NEW CONCEPTS AND THE MODEL 55

In 1928, several very important influences matured for Atwater Kent and his radio business. He was enjoying the fact that he was the world's largest manufacturer of radios and that his vision had gotten him to that position. The growth of his business had been impressive, only eight years having passed since he started with radio parts. The profitability of his radio production had steadily increased and he was in a position to further increase the business. Although the design of his sets, as evidenced by the capability of the Forties Series, was mature, further development and better manufacturing techniques were required. The metal-box style was accepted by his customers but a new style, the console radio, was becoming popular and indicated a new direction for his growth.

The new factory building at 5000 Wissahickon Avenue had started to demonstrate its value for modern manufacturing. And there were a number of new manufacturing practices that he could put into place. One was assembling the radio and audio circuits and parts along with the power-supply components on a single chassis. Another was testing and adjusting the radio only one time in the assembly process, instead of the multiple testing done on separate major assemblies. Best of all, new vacuum tubes were being developed and could be used to build superior radios without

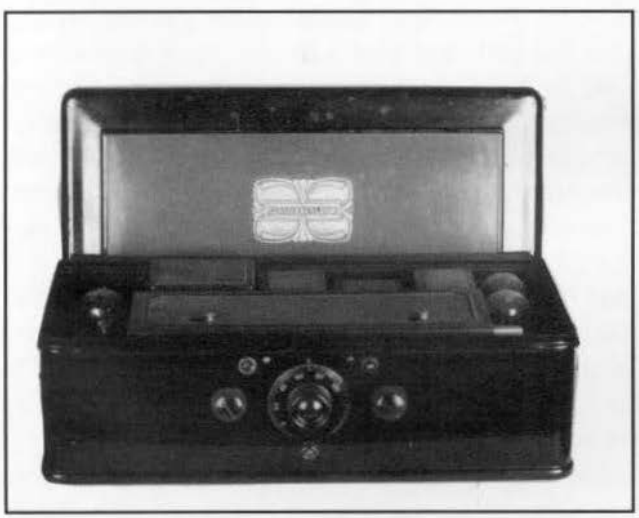


Figure 55. *Model 55. Kent combined all the good features of the metal-box radios into one top-of-the-line design. It was produced both as a closed box and an open chassis for inclusion in a console.*

a major impact on engineering or manufacturing. To incorporate all these new concepts, Atwater Kent's engineers started on a new receiver design. It was to be the Model 55, No.14900, Figure 55.

During the first World War German scientists studied the triode and the effects of extra electrodes on its performance. Their work led to accurate characterization of the tetrode, but it was not used by American tube manufacturers to develop a commercial version until the middle twenties. When it appeared in 1926, the dc filament version was designated type UX222. For electric radios, it was necessary to incorporate the uni-potential cathode for ac use. That development work took place in 1928 and the result, the type-UY224, was announced in April, 1929.

Incorporation of the second grid in the type-UY224 resulted in substantial changes in the behavior of the tube. One action of the second grid was the isolation of the control grid from the plate. It was, in effect, a screen, and this function gave the new tube its valuable advertising name, the screen grid. This meant that the feedback, common in triode RF-amplifier circuits, would not upset the action. The damper resistor that Kent had used since the Ten-Series days could be eliminated. Another characteristic change was to reduce the effect that the plate voltage had on the electron stream, thereby increasing the plate resistance and the amplification factor. Because of these different tube parameters, the screen-grid tube could be used as a stable, high-gain radio amplifier without neutralization. As soon as RCA made data about the type-224 tube available in 1928, the opportunity to develop a new line of radio receivers caused a major stir in Atwater Kent's engineering activities.

A whole list of new requirements had accumulated; here was the opportunity to meet them. For the first time in nearly five years, the radio amplifiers in Atwater Kent's receivers could be redesigned (of course the tuning condensers, the tracking bands and the general layout were still acceptable), but the coils and their circuits, their orientation and their mountings, had to be new. Earlier receivers using triodes included very little bypassing, but with screen-grid tubes, screen and cathode tie-downs became important. Consequently, the older style of tube sockets and attachments were inadequate for the resistors and condensers needed in the new sets, so new ones were designed for the new set, the Model 55.

The power supply and the audio circuits for Model 55 were adapted from Model 46 with minor changes, that is, the transformer voltages and the enclosures. The audio-output tubes were changed to type 245 and the filament circuits for the whole set were fixed at 2½ volts. The big change was the use of two type-224 tetrodes as radio amplifiers instead of the type-26 triodes that had been used in earlier sets. Frequency selection was done by tuning the secondaries of the three inter stage

transformers. The primary of the first transformer was a part of the antenna circuit. The output of the fourth (untuned) transformer was fed to a type 27 tube connected as a power detector. Kent called this circuit a 'plate detector.' The increased stage gains (and improved selectivity) of the RF amplifiers made a power detector practical. The result was a very sensitive electric radio with higher output power and lower harmonic distortion than anything Atwater Kent had produced before.

Two types of Model 55 were produced. The differences in the two types were in three functions, the RF inter stage couplers, the volume controls and the distance switches The early one used transformers and the later type used tuned auto-transformers for the RF stages. The early type used a single-element variable resistor, connected to vary the screen voltage of the first RF amplifier for volume control. The later type used a double-element control. One element was in the antenna circuit and the other element changed the screen voltage on both RF amplifiers. The distance switch on the first type simply selected either a part or all of the primary of the first inter stage transformer, but on the second type the switch connected or disconnected the plate output of the first amplifier stage.

Mechanical integration of the power supply in the total radio enclosure was the requirement that had been met only marginally in the Forties Series electric sets. Taken together, these new demands, and the results of earlier successes, called for a totally new mechanical design. The days of the steel cabinet were numbered, but the superb metal-shaping facilities that Atwater Kent had developed were still in place. The metal-box receiver was the chosen style, but the separate RF/AF chassis and separate power-supply construction was not the way to go. Integrating these demands in a new, producible, easily assembled mechanical structure was the right way, but this called for another first in the Atwater Kent line of radio sets. It was the concept of a planar chassis with shallow, stiffened edges, whose structural strength was sufficient to support all the components in the receiver during assembly and shipping. Its shape was selected to simplify fabrication, and its size, 10½ inches by 21½ inches, was chosen to fit into the steel cabinet used for Model 45.

The change to a single, large chassis was a cost-reduction, in so far as assembly was concerned, but it also incurred an expense. New presses were required to stamp out the new chassis. The factory had to be equipped with larger presses than those that shaped the metal-box enclosures used for Model 45 (and the other large receivers) and the metal consoles. The reason for the bigger presses was the shape of the Model 55 chassis. It was a medium-draw stamping but it had turned edges. The investment for Model 55 would be recovered if later sets needed a similar chassis, so Kent implemented the single chassis design.

This change in design permitted a consolidation of the manufacturing processes. With the full chassis only one manufacturing sequence was required because the power supply components were no longer assembled in a separate unit. The assembly sequence was easily duplicated on separate lines. As many production lines as the volume of sales justified could be set up or taken down at minimal expense. The main cost for an assembly line was in the final test and adjustment station, and this cost was moderate. Kent established the means for low cost, high quality, complex radio-receiver production.

Model 55 used a vertical panel fastened to the main chassis to mount the tuning condensers. Kent retained the band-and-drum system for ganging the condensers, and on all but the very first Model 55s mounted a vernier-tuning mechanism on the condenser panel. The main enclosure (the metal box) was windowed in the front and faced with a gold-plated escutcheon revealing the dial. The first version of Model 55 did not have the window but used the same dial as the Forties series. Model 55 was made available as a panel set. The difference was that no enclosure (metal box) was sold with the chassis.

At the time of Model 55's design console radios had become prevalent enough to make their requirements a part of any new radio. Atwater Kent, realizing the trend toward wooden floor consoles, arranged the design of the chassis to accommodate a metal dress-panel fastened to the front of the chassis through which the control shafts passed, and on which the dial escutcheon was mounted. The panel was finished in simulated wood-grain; the escutcheon was gold plated. The panel closed a big opening (9" wide) in the face of a console. A chassis that included the dress-panel was marked with the suffix letter "C." In addition to the 60-Hertz console set, Model 55C, No. 14800, Kent produced two 25-Hertz sets, Model 55F, No. 15600, supplied in the metal box and the corresponding console set, Model 55FC, No. 15700. For the metal-box sets, the chassis was fastened to the bottom edges inside the enclosure. The console set was fastened with screws passed up through the shelf to the captive nuts in the lip if the chassis. Both styles used a flat metal cover fastened to the bottom of the chassis to protect against dust and interference.

Model 55 used an electro-dynamic speaker to produce sound. Atwater Kent produced a series of these speakers, all based on the Model F. The differences were in the enclosure and the rating of the field coil. They were Models 2 through 7 with suffix letters A and C. The A indicated the large diameter enclosure, whereas the plain number was used for the smaller flanged speaker. The suffix C indicated use in a console.

Atwater Kent had not started to ship his radios in wooden consoles. His dealers made them available to their customers, but they were made

by other manufacturers. His advertising made a point of telling the customers about their many choices but they were not products that went through the Philadelphia factory. Model 55 and the sets in the Sixties Series became the main sales attractions for the 1929/30-holiday season. The quality of sound from these sets was quite good, especially to listeners whose experience came from the typical magnetic speakers of that time. It was with Model 60 that Atwater Kent started his campaign to emphasize "Tone."

Chapter 12

THE SIXTIES SERIES

MODEL 60, No. 15000, AND MODEL 60C, No. 15100

Atwater Kent provided a full line of radios in the 1929/30 model year, the Sixties Series. The first one was Model 55 and the next was Model 60. In past series, the sets started with the same digit, e.g., the Forties Series with Models 40, 41, 42, etc. The Fifties Series was anomalous because Model 50 was a battery set related to the Thirties Series and Model 55 was the first of the Sixties Series. Keeping track of the progress of radio development in the Atwater Kent factory was not based on the 'series' concept even though it had been used for earlier radios. The 'series' idea tended to be a customer-oriented way of looking at a product line. Kent had succeeded in five increasingly mature markets. The pattern of customer preferences was clear: A bottom of the line set, a better set, and specialty sets for different power systems. The business aspect of the pattern was equally clear: The underlying design, both electrically and mechanically, was common and no unique manufacturing facilities and practices were to be used.

Model 55 was the base of the Sixties Series. It was the seven-tube screen-grid set. It was also the set in the Sixties Series that met the different 25-Hertz ac-power requirement, Model 60 was the eight-tube set that appealed to the customer who wanted a better set than Model 55, but it was not made for use on 25-Hertz systems. The rest of the series was: Model 61, the set used on dc-power systems, Model 67 built to be powered with A, B, and C batteries, and the high-powered set, Model 66.

Model 60, Figure 56 was assembled on a chassis that was very similar to Model 55. It was the same size, fitted with many of the same components and used the same general layout. The added third-RF amplifier was placed on the left end of the RF section. To make room for the extra tube and coil the others were moved a little to the right. The Model 60 tuning condensers were not moved from their positions in the Model 55. Instead the fourth condenser was added at the extreme left. This required an extended vertical bracket, the only significantly different fitting in the set. The added RF stage was designed and wired in the same manner as the second stage in Model 55. An important difference between Model

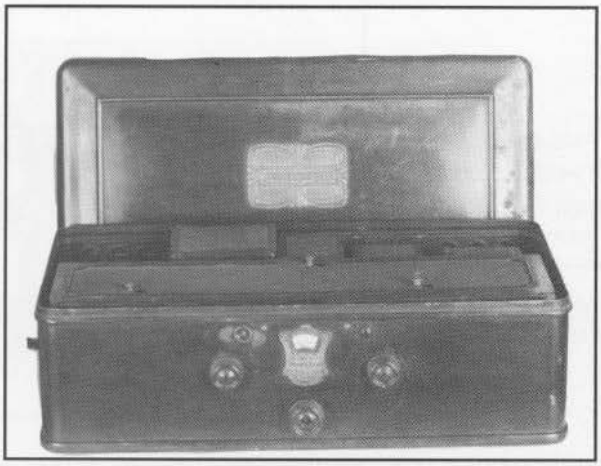


Figure 56. *Model 60. Reflecting the need to market a new set each year, Kent made minor changes to the earlier set. It was not dramatically different.*

55 and Model 60 was the plate voltage of the double audio-output stage. It was raised from 175 to 250 volts to provide more power output. The main power transformer and the output transformer were changed accordingly.

Model 60 came out in early and late Types. The variations of the RF-transformer style, the distance switch and the volume control that had differentiated between the two Types of Model 55 were retained in the Model 60. In the same way, and using the same stamped-steel metal-box and the same dial and escutcheon, Model 60 was made available to listeners who wanted a table radio. The selection of loudspeakers was the same for both Models. Model 60C, No 15100 was the console chassis that bore the same relationship to Model 55C, No. 14800, as the metal-box sets bore to each other.

MODEL 60C, THIRD TYPE

In June of 1929 Kent published a very attractive sales pamphlet describing the radios in the Sixties Series and their loudspeakers. For each set, the console model is listed first. This order of identification can be interpreted as a reflection of customer preference, an indication that the metal-box radio had reached the end of its strong appeal. At that time Atwater Kent and his factory were riding the crest of the success wave. They produced a very good radio, had established a fine reputation and enjoyed a national reputation as the top radio manufacturer. Kent's customers tended to be the high-middle class of the American economy. His radios suited their taste, but without his recognizing it, his market was narrowing to the place where his future would become questionable.

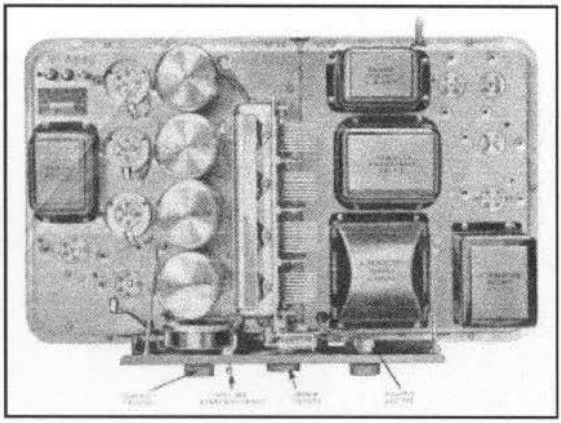


Figure 57. *Model 60C, Type 3. Kent was working on a new chassis design that eliminated the belt ganging. It was scheduled for the Seventies Series so he tried it using this set for the experiment.*

Clearly he was meeting his customers needs. If that market continued to be stable, his business would remain stable. But the big expansion upon which he had built the Company had depended on new markets for new sets. And at the time of Model 60 Kent was not planning for a new market. He had chosen the console with its high-quality chassis in favor of the table set and had not even approached the midget market.

During the time that the Sixties Series was being brought to market, Kent's engineers were working on an advanced version. The radio was another Model 60 electrically, but the mechanical layout was quite different. By that time, late in 1928, the technical and manufacturing people realized that tuning condensers ganged with belts and pulleys were not as easy to produce and not as effective for servicing as ganging with a single-shaft, multiple-section condenser. The Kent patent had reached the end of its cost-effective life and had to yield to the Hogan patent!

The new radio that they were designing was identified as Model 60C, Third Type, No. 15100, shown in Figure 57. To get enough front-to-back depth for the four-gang tuning condenser, they designed a new chassis. The shape and specific width of the new chassis were the same as the early type Model 60, but its depth was changed from 10½ to 12½ inches. Component layout was altered to facilitate lining up the RF amplifiers from front to back alongside the condenser sections; the RF coils were placed between the two.

The extra depth of the chassis required new dies for the press that stamped it out of sheet stock. It might have been within the capability of the presses used for the Sixties Series but would have been marginal for stamping force and rate. Model 66 had already been committed and it too required the large chassis. The new chassis was the biggest one that Kent's presses had made. It required new dies and probably pushed the presses used for Model 55 and the first Model 60s to the limits of their drawing force. For a short run, (and this receiver was not expected to

rival Model 55 for popularity) the use of the largest press might have been acceptable.

This receiver, however, had another purpose. It was the experiment to assess the number of big presses needed for extensive production. Kent's engineers devised another way to get around the problem of the bigger presses. An immediate, although temporary, solution was to divide the big chassis into two smaller ones and stamp out those two complimentary sections with the presses used for Models 55 and 60. Then, as the first step in assembly, permanently fasten them together before starting the component assembly process. The two sections of the chassis were the right section, 9½ by 12½ inches, and the left section 11 by 12½ inches. They were fastened together with a channel piece to which they were screwed. The tuning condenser was mounted on the left section so that it was centered on the total chassis.

Model 60C was successful in its experimental role. It provided the basis for the next group, the Seventies Series. The circuits of Model 60C were almost identical to Model 60, even to having an early type and a late type whose main difference was the RF coils. The electrical design had almost become standard. The RF amplifiers were three type-24 tubes, the detector and first audio amplifier were two type-27 tubes, and the output amplifiers were two type-45 tubes. The rectifier was a type-280 tube.

Model 60C could be considered the bridge between the Sixties Series and the Seventies Series of Atwater Kent receivers. The circuit improvements and the mechanical development of the chassis with their implications for factory tooling indicate the order to be Model 55, Model 60, Models 61 and 67, Model 66, Model 60C Third Type, and finally Model L, the first of the Seventies Series. The dates of the service instructions tend to support this order. Model 55's first release was September 1929. The Service Manual was updated in March 1930 to show data on Models 55, 60, 61 and 67. Next, in May 1930, a new section of the Service Manual, starting on Page 201, was released to provide extensive data on Model 60C. In December 1930 the factory released the next section of the Service Manual. It covers the Seventies Series. The service instructions were always later than the dates of first sales, sometimes by as much as three months. Therefore, it looks as if Model 55, and probably the early Model 60, were intended for the Holiday season in 1929, and the first of the Seventies Series, the type L-1 Chassis and its variety of consoles, were intended for the 1930 Holiday season.

MODEL 66

The top-of-the-line radio in the Sixties Series was Model 66. Its circuit was very similar to the late Type Model 60 but with one very important

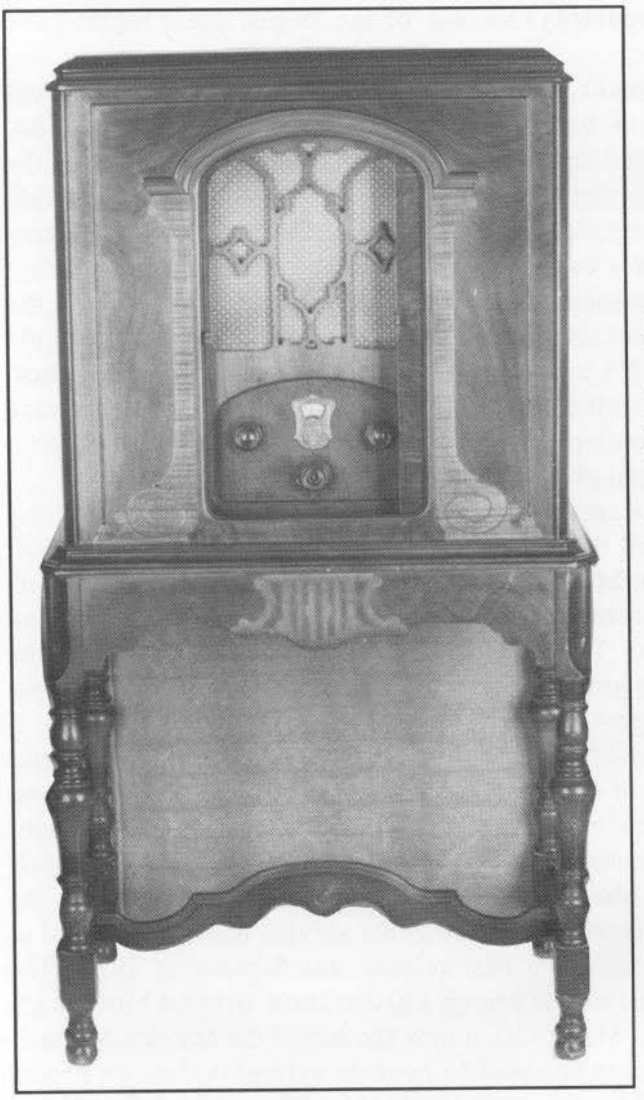


Figure 58. *Model 66. This was the highest power TRF set that Kent made. It used two type-50 and two type-81 tubes and had a special loudspeaker.*

difference; the specified output power. This included the tubes, transformers, and loudspeaker. The set was designed to produce much more output power than any predecessors. The output was produced by two type-250 triodes operated in Class A with 450 volts on their plates. They were rated for almost 5 watts (undistorted) with a moderate input signal to the receiver.

Bias for the output stage was the drop across the field coil of the loudspeaker, connected in the return lead of the power supply. The 450 volts for the plates and the bias voltage of 84 volts was well over the ratings of the type-280 rectifier tube, so a pair of type-281 tubes were used as the rectifier. Separate plate and filament transformers were used in the power supply.

The chassis of Model 66, Figure 58, had to be larger than those in the rest of the Sixties Series. (At the time of release of Model 66, Model 60C, Third Type had not been designed). Model 66's chassis was the same width as the earlier ones, but its depth was increased by two inches to 12½ inches. New dies were required and they took more capability from the press to stamp out the larger chassis. Model 60C, Third Type also needed the larger chassis, but it used a built-up chassis instead. The presses used for the smaller chassis were seen to have been marginal for stamping out the larger chassis on a production basis. Since Model 66 was not expected to be a large-quantity item, the marginal presses would have served. For high-production rates, new, larger presses were required.

The arrangement of the RF and detector section of Model 66 was the same as for Model 60, Late Type where the auto-transformer-style RF coils were used. Volume was controlled with a dual potentiometer, one section connected to shunt the output of the first-RF amplifier and the other section connected to change the cathode voltage on all three RF amplifiers. Model 66 did not have a distance switch.

MODEL 61, NO. 15300, NO 61C, NO. 15400, MODEL 67, NO. 15500, MODEL 67C, NO, 15600

In producing a 'series' of radios, Atwater Kent found that there had to be some specific models. There had to be a low-end set, a middle set, a high-end set, one for listeners who were served by dc mains, and a battery-powered set for the people who did not have delivered power. Model 61 was built for service on dc mains and Model 67 was built for battery power. The main circuits in both of these radios are nearly identical. Both used the same tube line-up; three type-222 screen-grid tetrodes for RF amplifiers, type-112A tubes for detectors and first audio amplifiers and type-171A output tubes. The big differences were in the resistor networks used to bias the various stages.

Model 61 was a table model set in a metal-box. It was accompanied by Model 61C, the same chassis equipped with the panel for use in the console-style radio. Both of these models were manufactured in the Early and the Late Types. The differences in Types were the same differences that had been made in Model 60; RF coils, distance switch and volume control. The chassis was the same as Model 60 except for the power-supply components and their punched out holes. Had Kent used Model 55 as the pattern for Models 61 and 67 with the dc tube line-up the overall amplification of the set would have been deficient. Therefore, he used the eight-tube set and obtained performance equivalent to that of the seven-tube ac set, Model 55.

The battery supply for Model 67 was recommended as four 45-volt batteries. With the type-171A output tubes the battery cost was high. If that much power output was not needed, a lower voltage was used. This made Model 67 almost the exact equal of Model 61 where the line voltage of about 110 volts controlled the output power. Part of the line voltage for the output-stage plate was conserved by the way the field coil of the loudspeaker was designed and connected. Model 61 used the Model F6 or F6C speaker, with its high-resistance, low current field. It was connected directly across the power line after the RF filters. Model 67 used the F7 or F7C loudspeaker with its low-resistance, high-current field. It was connected across the A-battery supply.

Both of these radios were popular, as indicated by their presence in collections. They are hard to show because their appearance is so nearly identical. The only distinguishing feature on the front of the set is the model number on the gold escutcheon. In a big space, a collector could show each of the Sixties Series radios in a different console. Kent made many different styles available through his dealers even though he had not yet started to sell the radios and their cabinets as complete radios.

Chapter 13

THE SEVENTIES SERIES AND THE LETTERED-CHASSIS TYPES

MODEL 70, L-CHASSIS, No. 16000

With the Seventies Series Atwater Kent introduced a new way of selling his radios. He put the emphasis on the console style, where before he had sold a chassis and his dealer helped the customer select a suitable console cabinet. He changed to selling the complete radio including both the chassis and the console cabinet. In the Seventies series he offered five console cabinets and six different chassis. The chart shows the dealer's offerings.

SEVENTIES SERIES CHASSIS NUMBERS

Model No.		Chassis Letters					
		L	F	D	Q	P	H
70	Lo-Boy 38" Ht.	16000	16100	16700	16800		
74	Table 30" Ht.	16000	16100	16700			
75	Phono 40" Ht.					16600	
76	Hi-Boy 48" Ht.	16000	16100	16700	16800		
72	Lo-Hi-Boy	Superheterodyne,					16500

The standard chassis was the 'L', an eight-tube receiver with three type-224 tubes as RF amplifiers, a type-227 tube for the power detector, and another type-227 tube for the first-AF amplifier. Two type-245 tubes were connected as a double (push-pull) output amplifier with a type-280 tube for the power rectifier. The circuit and the mechanical layout were very similar to the Model 60C, third type. A new loudspeaker, the type N, was designed for Model 70, Figure 59, and the other radios in the Seventies Series. The other chassis in the Seventies Series were: Chassis 'F', No. 16100, used for 25-Hertz service, 'D', No. 16700, for dc mains,

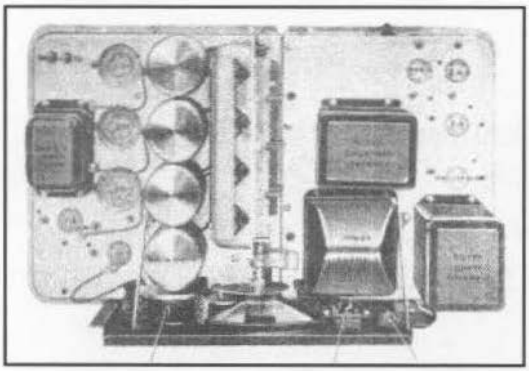


Figure 59. *Model 70, L Chassis. The difference between this set and the one in Figure 58 is the output transformer which was moved to the loudspeaker frame.*

and 'Q', No. 16800, the battery set. The 'P' chassis was designed to include the operation of a phonograph, so it required the Model 75 phonograph console.

The consoles were: Model 70, the Low Boy, Model 73, the Low High-Boy, Model 74, the Table (not a table model but a low cabinet about the height of a table), Model 75, Figure 60, the Radio-Phonograph, about forty inches high, and Model 76 High-Boy. Every chassis was the same size as the others and every console had the same space on its shelf for the radio. There was nothing to preclude a customer from buying another combination than those standard ones shown above. Today's collectors don't always have the Kent-recommended combinations on display.

When the factory started making a chassis big enough for the Seventies Series radios, there were not enough presses in place to meet the production requirements. The total number of presses was adequate but their capacity was limited to the size for Model 55 and Model 60. The mechanical engineers responsible for chassis design devised a suitable division of the big chassis into two smaller ones, which were fastened together before electrical assembly. (See Model 60C, Third Type.)

For the Seventies Series a new dial mechanism was designed. Earlier, the dial numbers had been arbitrary. With Model 60, a red overprint of frequency was added to the dial plate but the high-frequency end of the dial was severely bunched. To even out the frequency intervals, a curved and slotted lever was added between a post on the dial plate and the pointer. The rate of motion between the shaft and the pointer was variable so that a half turn of the condenser shaft resulted in a quarter turn of the fan-dial pointer, and the pointer rate approximated a linear-frequency indication. This was due, in part, to the linkage action, but it was also enhanced by the rotor shape of the variable condenser. The fan dial that started with the Seventies Series became a characteristic identification of Atwater Kent consoles. It was retained for several years.

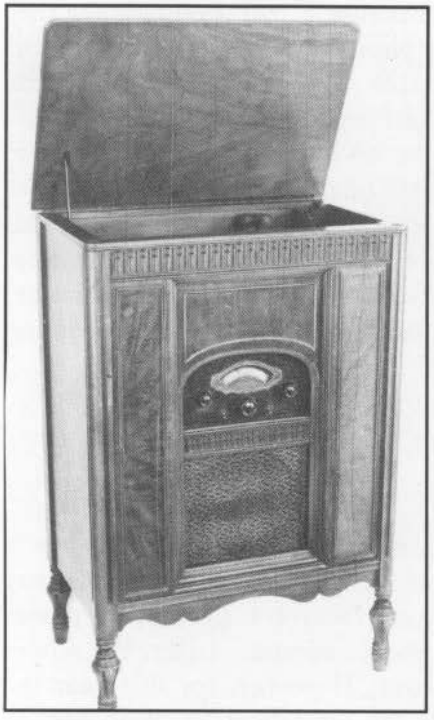


Figure 59A. *Model 75, Phono. By increasing the Model 70 height four inches, a compartment for the record player could be accommodated. The pickup was the RCA Cobra Arm with the magnet cover stamped with the Atwater Kent logo.*

Model 70 was also the standard Atwater Kent receiver in the Seventies Series for 25 Hertz operation. The difference between the 60-Hertz set, Chassis No. 16000 and the 25 Hertz set, Chassis No. 16100 was only in the power supply. Chassis No. 16100 was designed with a power transformer and filters that were rated for 25-Hertz operation. From a manufacturing standpoint or for operation, the two chassis were alike.

For Model 75, the radio with the phonograph, both the cabinet and the chassis were a little different from Model 70. The console was somewhat taller, enough to accommodate the turntable and the electric pickup. The

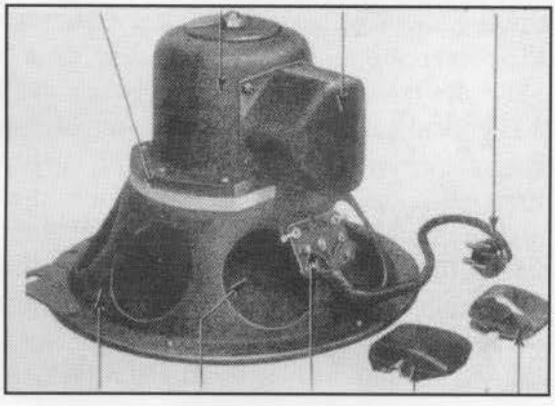


Figure 60.
Type-N Loudspeaker. This unit was fundamentally the same as the F series. The difference was in the field enclosure, its attachment to the frame and the inclusion of the output transformer.

chassis, No. 16700 was different only because it had terminals for the pickup signal and a switch to select the phonograph signal. The switch replaced the distance switch. The turntable was mounted on a dressed motor-board that was fastened to the shelf just under the hinged top of the console. The pickup spindle and the on-off switch for the motor were also mounted on the molded motor-board. The pickup was the RCA Cobra Arm. Its magnet cover was embossed 'Atwater Kent' instead of 'RCA'. Here is another example where Atwater Kent does not hesitate to use the best of someone else's work when it enhances his product or his name. He also did not hesitate to use his own name when it was negotiated with the patent holder.

THE MODEL 70 D-CHASSIS, No. 16700, AND THE Q-CHASSIS, No. 16800

The system of radio-set identification hitherto used in this review is limited by the changes that the Atwater Kent Manufacturing Company made in identifying the 1930/31 model-year receivers. Earlier, the power source for a radio was apparent in its model number. Later, the power source was identified by a terminal letter. However, for this year the Model number did not always provide the identification. Also needed was the Chassis number. To exemplify beyond the chart in the previous segment of this review, Model 70 was operated from the dc mains and it was therefore shipped with the chassis that used dc power, the 'D' chassis, No. 16700. Model 70 was also a battery set. In that configuration it was equipped with the 'Q' chassis, No.16800.

The D-chassis and the Q-chassis were almost identical in their signal-processing circuitry. Both used three type-222 tetrode tubes for RF amplifiers, a type-112A tube as a grid detector, another type-112A tube as the first-audio amplifier, and a pair of type-171A triodes as the 'double audio-output amplifier.' The left portion of the metal stamping for the D- and the Q- chassis were the same. The right portion was the means of carrying the power-supply components; they were very different from each other and from the L chassis. The D-chassis did not have a power transformer, and instead it used a larger filter assembly which required a minor mounting rearrangement of the other power supply components. The Q-chassis eliminated the transformer and filters that were used on the L-chassis, and in their place mounted a battery container for the bias batteries.

Volume control on both chassis was similar, a dual variable resistor. One section, a potentiometer in the antenna circuit, was used to vary the screen voltage on the RF-amplifier stages. The loudspeaker for the D-chassis was the Model F6 or F6C. Its field was connected across the dc

mains through suitable filtering. The Q-chassis used an inductor loudspeaker, Type-J, for console applications, Another loudspeaker that used the same sound unit was Type-JB, No.17010, a cathedral-shaped metal cabinet that sold as an auxiliary loudspeaker to complement the Model 70 or 76 receiver.

The Seventies Series was the last of the Atwater Kent radios to offer Tuned-Radio-Frequency design and performance. In the series, the first of the new kind of radios, the superheterodyne, was offered. The new set, the H-chassis, No. 16500, marked the end of a decade for Atwater Kent that saw him transition from a maker of automobile engine parts to one of the best producers of radios for a new way of American life.

Chapter 14

AFTER THE TUNED-RADIO-FREQUENCY SETS

ATWATER KENT LICENSES THE SUPERHETERODYNE

By 1930 Atwater Kent had become a household name. His radios had played a significant part in the development of the modern society of the twenties. During those years Atwater Kent's business of making and selling radio sets had steadily grown from the simple five-tube open set, typified by Model 10, to the nine-tube console with its deluxe metal chassis and super-power output that was Model 66. By contrast, his first sets, in 1922 and 1923, had produced only a few milliwatts of power to drive a magnetic diaphragm loudspeaker.

The circuits of his radios had all used tuned-radio-frequency (TRF) amplifiers. They became more powerful, and he provided better quality audio amplifiers and speakers as time went on. Model 66 could generate an output nearly one thousand times greater than Model 10, and could do this with an antenna signal ten times smaller. Kent's cabinets had gone through the wooden and metal-box phases and were now nearly all consoles.

Atwater Kent radios progressed from the dramatic curiosities with which he introduced radio to the general public, to imposing necessities in the living rooms of the upper-middle class. During the twenties Kent's radios bid fair to continue their progress into the thirties even though the sets were priced in the upper-middle range, with a consequent limitation of customers ready and willing to pay higher prices for Atwater Kent radio sets, regardless of their features.

But the complacent acceptance of conditions in the 1920s was not completely valid. Economic growth was sustained by the favorable social conditions of that decade. It reflected the general feeling of well being of the period. But hidden under the booming prosperity was the unrecognized basis that supported the good times, and unrealized was the unattractive truth that the growth was carried on the back of extended and extensive credit. When credit became excessive, minor changes in the flow of on-going business, always present in a free society, caused major fluctuations in the society's general economic condition.

In normal times, such changes are accommodated by the economic resilience of savings and reserves that conservative businesses use to protect themselves. By the end of the twenties, however, credit expansion had gone further than business resilience could compensate for, and much of the financial structure came tumbling down. The economy of the country had reached the end of a spiraling boom and was experiencing the wrenching beginning of a painful depression.

For radio manufacturers the immediate result was excessive inventory, reduced production, with consequent layoffs and substantially reduced cash flow, especially reflecting the repossessions caused by the non-payment of installment contracts by hitherto optimistic radio purchasers. For Atwater Kent, it marked the beginning of the end of the growth of his radios in size, performance, and appeal to the affluent. The TRF radios that had become the mainstay of his business faced a cloudy future.

Unfortunately for Kent's business, the broad market for big radio sets was disappearing. Kent, whether he wanted to or not, had to replace his big TRFs with a product line which would appeal to those who could only afford less-expensive sets. That meant he had to produce small sets, but not the little TRFs that he had left behind three years before.

Like other manufacturers he wanted to go to a new design, but the radio-patent situation was a serious constraint. How that problem was solved involved the Radio Group and the Department of Justice. For the Radio Group (Radio Corporation of America and its owners, General Electric and Westinghouse) this period marked the end of its existence. They had put together a cross-licensing agreement which had given RCA its existence, but which also had the potential of limiting competition in the radio-manufacturing business.

For the independent radio manufacturers, this time was the end of their business unless they could license the patents of the Radio Group, at royalty rates that could be supported by production and sales in the limited market of the depression period. Various independents had sought licenses from RCA for devices and circuits which would have made them effective in competing in the radio business. But RCA was reluctant to grant licenses, except at royalty rates that the independents considered so exorbitant that they complained to the Justice Department. They particularly wanted to license the patents related to the manufacture and sale of the superheterodyne.

For RCA itself, this period was the metamorphosis of a well-regarded sales organization into an independent radio-manufacturing business. When the RCA was formed, one of the intentions of the General Electric Company was to maintain its manufacturing business in the new radio field. It therefore included, in the charter agreements, the concept that

GE would not sell consumer radios directly but would accept RCA as its sales agent. Inherent in the concept was its antithesis; RCA would not have manufacturing capability for consumer radios.

Shortly before this time, in 1928, the Victor Talking Machine Company realized that their limited entry into the radio business years before was fatal, and they wanted to sell out. The Victor facilities in Camden were, in RCA's view, an ideal means for it to become a manufacturing company, so these were added to the RCA holdings.

For the Department of Justice, the period was a major and successful fulfillment of its obligation to implement the anti-trust provisions of federal law. The Department of Justice considered itself the proper watchdog for examples of restraint of trade. It didn't like the tightness of relations among RCA and the remaining owners, General Electric and Westinghouse. Moreover it particularly disliked the restriction of licensing about which the independents complained. It therefore started investigating the Radio Group to learn whether or not there were violations of the Sherman Act. The Justice Department wanted to break up the patent pool, but at the same time it felt constrained about potentially destroying the radio industry.

A critical factor behind all the difficulties outlined above was the technical fact that the TRF receiver could not be profitably produced in the size, style and cost that would make it effective in competition against the superheterodyne. All of the independents wanted to build superheterodynes, but RCA wasn't making it easy for them. RCA seemed to want to hold the little superheterodynes off the market, since it did not seem to recognize the necessity of going to the small-size radios as a new product line, even for itself. In retrospect, this period looks a little like a standoff.

The solution took about four years to become final. Early on, RCA bought Victor and started its internal campaign in the Radio Group for independence. It also heard the message from the Department of Justice and loosened its (and its owner's) licensing policy. By 1930 the independent radio manufacturers were able to license superheterodynes, and could therefore plan sales campaigns around new styles, superior performances and sharply reduced prices. RCA worked out a new relationship with its owners, in which they divested themselves of both ownership and control.

All of the former Radio Group together arranged a patent pool for non-exclusive patent sharing. The Department of Justice was satisfied that its requirements had been met. At the end it concurred in a consent decree that made RCA totally independent, and granted it the same patent arrangements with its former owners that it was permitted to make with outsiders.

Atwater Kent was a major beneficiary of the new RCA (which by this time had become RCA-Victor). He was able to bring out a new line of radios, the superheterodynes. While they embodied all the qualities

on which he had built his business, their advanced design freed him from the very difficult situation of having to push the large, limited-appeal TRF consoles.

The basic form of the superheterodyne radio that Kent produced is shown in Figure 61. Included is a way of combining a desired signal with another, locally-produced, wave. The combiner was called the mixer or converter. The difference frequency between the two frequencies coming into the mixer was called the intermediate frequency (IF), and was the output taken from the mixer. It was then amplified in the IF amplifier and passed on to the detector. Processing the desired signal before it was fed to the mixer and separating it into its components after the IF amplifier had increased its amplitude were functions that were added to the basic superheterodyne concept.

Kent had to license the basic concept before his organization could sell the circuitry that they had developed. Emplacing facilities to produce superheterodynes before they could be sold to the general public was a risk that Kent felt was necessary if his company was to survive.

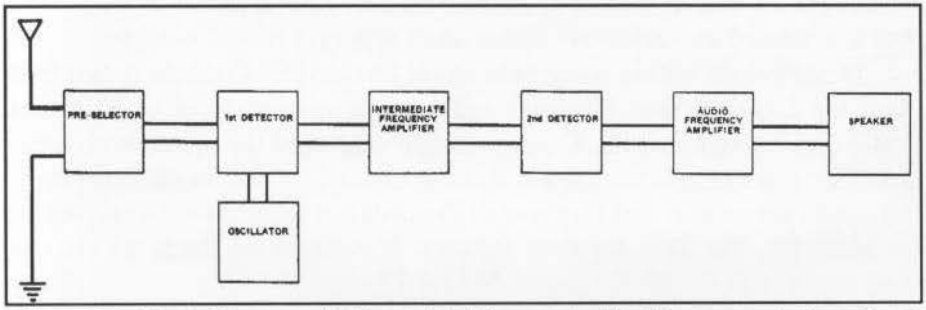


Figure 61. *Block Diagram, H Chassis. This was the first Kent superheterodyne. It was classic and could only be sold in the high-end market.*

Chapter 15

ATWATER KENT'S NEW PRODUCT LINE

THE MODEL H
THE EIGHTIES AND NINETIES SERIES

The next part of this review of Atwater Kent's radios is made up of five segments. Two of the segments are the Eighties and the Nineties Series. The rest are the Model-year Series. Together, the segments endeavor to cover all the known alternating-current-powered superheterodyne radios that Kent produced. Included are descriptions of the circuits in the radios to exemplify what the factory did to assure design maturation. Radios powered from the direct-current mains, radios energized by batteries, radios for 32-volt dc-power systems, and automobile radios are included but are treated as variations rather than separate model designs.

Descriptions within a segment cover five styles: Console radios that used the large chassis, Compact radios with medium chassis, Compact radios with small chassis, Console radios that used the medium chassis, and Console radios that used the small chassis. A list in each segment tabulates the sets in that segment in the order of their circuit complexity or maturity. The first segment follows. It is based on the large chassis and starts with the H-chassis of Model 72.

The short period of time when Atwater Kent changed his product line from the exclusive manufacture of TRF sets to superheterodynes was also the beginning of the great depression. This coincidence is a fascinating vignette in the history of radio in the United States that ties technical, economic, social and legal factors directly into the development of Atwater Kent's story. In the following reviews, the effect of limited customer purchasing power can be seen in the design of the radios.

THE MODEL H

Well before 1930 Atwater Kent's engineers had started experimenting with a superheterodyne that they could bring to market. To produce the new set they had to meet a number of serious requirements, not all of which were of a design nature. The question of producing a superheterodyne receiver resolved itself into three more: When? How much investment?

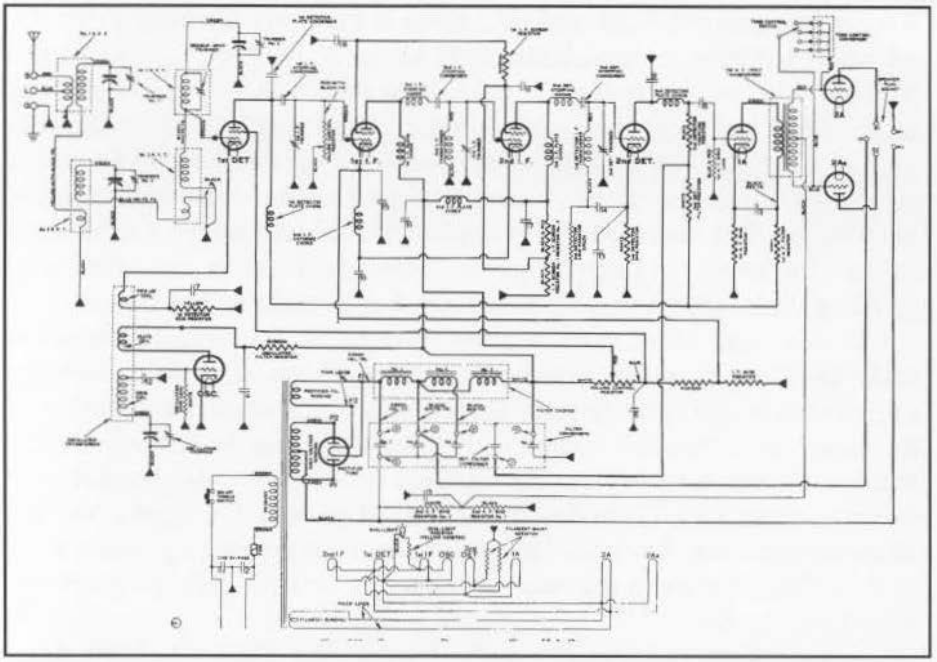


Figure 62. *Circuit Diagram, H. Chassis. Careful review will show that Kent's engineers used the Model 70-L chassis radio to develop their superheterodyne.*

And part of what factory production? The timing question was controlled by the patent license. The investment cost for design and production engineering was critical. Cost had to be controlled, so the new set had to be compatible with the sets being produced and marketed at the time of its introduction. It had to incorporate reasonably standard parts that were similar if not identical to those used in the main line TRF production. Fitting a superheterodyne into an existing TRF-production process could be done quite reasonably with a compatible design and simultaneous assembly. If the new set had to replace the TRF production instead of expanding it, the cost would have risen substantially and the continuance of the company would be threatened. Going to a completely new design, produced independently in a plant no longer making the earlier TRF sets, would have meant losing a model year with the consequent loss of income. This would be serious because it would occur at the time when sales were already suffering from the initial effects of the depression.

A full-fledged introduction to the market was also costly. Bringing out a new style along with the new circuit required a major sales campaign and suitable advertising, a too-expensive program if the TRF console market was still active and drawing on the company's resources. It would have been nearly overwhelming if it had to be done on short notice.

Because the date that Kent could introduce the new set depended primarily on when a license arrangement could be made with RCA, who owned the patent, a quiet introduction of the new style was the way to go. For future sales, a smaller chassis was a better choice since the sales potential of console radios was diminishing, However, getting a radio into his customers' hands was far more important for Kent than waiting for another model year. The experience of producing the set, the reaction from some of his customers, and the image of being progressive, all more than justified the cost of using the Seventies-Series radio to get started.

By this time, 1930, there were no mysteries in the circuits that would make satisfactory superheterodynes. The engineers of all the competing radio manufacturing companies shared both the historical knowledge of the superheterodyne that started with Armstrong, and the newer technical evaluations that derived from the standard vacuum-tube circuits that were directly applicable. Tetrodes had replaced triodes for amplifying the radio frequencies. Tetrodes had also been used for mixing frequencies in the effective manner that was necessary in the first-detector stage of a superheterodyne.

Atwater Kent had to make a high-risk decision. He had to start setting up production before he had obtained his license. The situation at RCA, however, pointed to the fact that he would eventually get a license. The actions of the Justice Department could be read to predict that outcome. Kent also had to choose how to fit a superheterodyne into his TRF production. He chose to expand the predictably successful Model-Seventies Series by adding the H chassis to the L, F, D, Q and P-chassis that were in production.

The first superheterodyne that Kent put on the market was a modified version of the L chassis from the Seventies-Series of TRF sets. The power supply, the audio system and the detector of the L chassis were carried over to the H chassis almost without modification (Figure 63A). The mechanical design of the two-piece, stamped L chassis, which became the main chassis of the H, was modified only a little. Another tube socket was added for the oscillator tube, and the audio inter stage transformer was moved from the right side of the layout to an open space behind the filter-condenser assembly. The main tuning condenser was retained, but its function was modified to tune the mixer, the oscillator and the input circuit.

A circuit diagram of the H chassis is given as Figure 62, and was included in the Service Manual for the H chassis. The second and third radio-frequency amplifiers in the L- chassis were converted to intermediate-frequency amplifiers in the H chassis. The first RF tube in the L chassis became the mixer in the H chassis. Its input operated over the same frequency range in both chassis, but the tuned circuits served slightly different functions. In the L chassis the input circuit served to match the

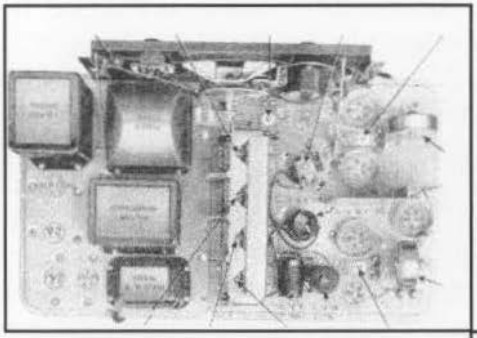


Figure 63. *Model-H Chassis, Early. Comparison of this Figure with the next shows the change in IF transformers that was needed to adequately shape the passband.*

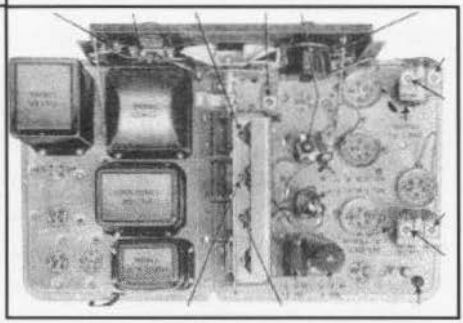


Figure 63A. *Model-H Chassis, Late. The IF transformers on the late set were double-tuned and slightly over-coupled. More important, they could be tuned after assembly to remove the de-tuning effect of manufacturing.*

antenna to the input of the first amplifier. This was continued in the H chassis but another, and very important, function was suppression of the image frequency. Atwater Kent called that function Double Spot Tuning. The concept was to connect one of the variable condenser sections and one of the RF coils in series across the input of the first detector. The circuit was tuned to track the image of the incoming frequency. The low impedance of the Double Spot Tuner circuit effectively shorted the image frequency, thereby eliminating the unwanted response. The fourth resonant circuit in the L chassis was changed to become the frequency-determining element of the local oscillator, and because of mixer action, the frequency-determining mechanism of the radio.

Chassis H was manufactured in two versions, divided at serial number 5,855,201. The early or H-1 version used simple coils for the resonant intermediate-frequency (IF) elements. With an IF of 130 kilocycles (kHz) the two single-resonant circuits would have been marginal for adjacent-channel rejection. The H-2 version used double-tuned transformers for the IF resonators and thereby secured more effective performance. Whether or not the transformer windings were slightly over-coupled, as later became standard, is not known at this time. Figure 63 shows the two IF-stage resonators as they appear when viewed from the upper side of their chassis. These are the easiest means to recognize the two chassis.

Volume was controlled in the H-chassis by means of a dual variable resistor, one section connected from the grid of the first IF amplifier to ground and the second section connected as a potentiometer in the B+

voltage divider. The first section of the variable resistor, in both the H-1 and the H-2 chassis, altered the impedance across the plate circuit of the mixer. As that value was lowered, less of the available output from the plate of the mixer was fed into the grid of the first IF amplifier, and thus less signal was available down the chain to be detected and amplified for the listener.

One of the limitations of bridging the IF amplifier with a low impedance was that the bandwidth of the amplifier was broadened as the gain was reduced. Consequently, with lowered gain, the interference from strong signals on nearby channels was increased. The H-2-chassis was an improvement over the H-1 in this respect (objectionable bandwidth increase) because the double-tuned transformers provided a much sharper IF roll-off.

The second section of the variable volume-control resistor was used in the H-1 chassis to alter the plate voltages on the two IF amplifiers. Lower plate voltage resulted in lower amplification, but on tetrodes such as the type 24A used in the H chassis, plate voltage was not an effective method of gain control. On the H-2 chassis the same voltage divider arrangement was used to alter the screen voltages on the IF amplifiers. This method would have been more effective since the mutual conductance of a tetrode is a strong function of its screen voltage. The better way of controlling volume was by means of an audio potentiometer in the output of the detector. This method came later; it was first used on Model 89.

THE EIGHTIES SERIES

In 1930, getting a compact radio on the market for the 1931 season was very important, perhaps vital to Atwater Kent. Producing a new style radio, with a new chassis and a smaller but high-quality speaker, put together with new assembly and test techniques, and most important, the new superheterodyne circuit, was monumental. Much of the planning and a good part of the detailed engineering could have been done early in 1930, but the purchase of new dies for the presses and new parts for assembly probably took place at the beginning of 1931. The goal appears to have been to get the new model radios into the dealer's showrooms well before the holiday season at the end of 1931.

Atwater Kent used the term "compact" to identify radios that were to be placed on a table or other independent support. Other manufacturers called them "mantel sets," or "table-models," even "midgets." These terms were not descriptors of the cabinets. Kent started by calling the cabinets "arches," and shortly after the end of the Nineties-Series only used the term "compact" for his table radios.

Three compact Models, 80, 82, 84, and their variants, five big-chassis consoles, 83, 85, 86, 87, 89, and variants, and Kent's first automobile

radio, Model 81, were the lineup for the 1931 Model year. All the compacts and all the consoles were superheterodynes, but the auto radio used the earlier TRF circuit. The design and production of the compact sets are first reviewed in this segment. Then the consoles, with their big-chassis designs, are reviewed.

The medium-chassis design was a single-piece sheet with two major folds that formed an open box 14 inches wide, nine inches front-to-back and two inches deep. The multi-gang tuning condenser was mounted above the chassis, in the center, with its dial arranged to show through a fan-shaped opening in the escutcheon fastened to the case. Tubes sockets were mounted in holes punched in the main surface of the chassis, with the power transformer fastened in an opening in one of the corners of the top surface. This design, with minor changes for different numbers of tubes and coils, was carried through several years of compact radio production.

Many of the radios designed with medium-size chassis (those in the Eighties Series and following) were produced with variant models. Some were made with the F-variation for 25-Hz applications, some with the D-variation for direct-current mains, some with the Q-variation for battery power, and some with the Z-variation for use on 32-volt dc home-lighting systems. There were also Early and Late Types, where minor circuit changes were incorporated without changing the existing model designation. Where these variations make significant contributions to the history of Atwater Kent's design and production of superheterodyne radios, they are identified in the review of the affected model. Otherwise the variants are listed without extensive review.

MODEL 84 EARLY

Model 84 does not seem, at first acquaintance, to be Atwater Kent's first entry into the compact superheterodyne market of the 1930s. Because the model number is larger, numerically, than two others, Models 80 and 82, it might appear that the Model 54 set also followed them. When some of the details of the Model 84 are analyzed, however, any sequence that starts with Model 80 becomes questionable. The circuit of Model 84 gives the first clue. Made in two types, the early set and the late set, this in itself is unremarkable, since Kent produced other early and late versions of a particular set, e.g., H-1 and H-2 of the Seventies Series. What is strange is that the tetrodes in the early Model 84 were type 24A while the same functions in the late Model 84 were accomplished using the newer tubes, type 35. Type-24A tubes were used in both versions of the H chassis and type-35 tubes were used in both versions of the Model 82.

The early Model 84 was probably rushed to market in early 1931 before type-35 tubes were available for general sale. In mid-1931 Kent made the late Model 84 available to his dealers along with the other sets in the 80 series. Another interesting refinement marks the order of the sets at the beginning of the Eighties Series. The first Model 84 did not have a tone control. On that set, the third knob was used for the on-off switch. Models 80 and 82 had a tone control, the third knob. A switch on the volume control was used to turn the set on and off. The late Model 84 also had the tone control and a switch on the volume control for the power function.

Model 84, early type, was a simplified H chassis with five tubes performing the superheterodyne signal-processing functions. The sixth tube was the power-supply rectifier. Kent carried over the mixer and a single IF tube from type 24A in the H-chassis to the same type in Model 84. The two IF stages in the H-chassis were reduced to a single stage in Model 84, so the gain in the detector had to be increased to maintain the overall gain of the simpler set near the earlier H-chassis value. Therefore Kent's engineers changed the second detector from a type 27 to a type-24A tube. The oscillator tube and its circuit were transferred directly from the H chassis to Model 84.

The other significant circuit change was in the audio-output amplifier. A type-47 pentode was substituted in Model 84 and the subsequent sets in the 80 series, for both the inter stage audio transformer and the pair of type-45 tubes in the audio amplifier of the H- chassis. The overall audio performance of the models in the Eighties Series was not greatly different from that of the H-chassis. But, the reduction in dollar afforded by the type-47 pentode, at the customer level, was substantial. Moreover, the value in size reduction of the radio was also substantial. These two improvements went far in making the compact a practical radio.

While the above analysis is based on the introduction of type-35 tubes, it is not the only evidence of the introduction of Model 84 before the others in the Eighties Series. The factory-drawing number tells the same story. The early set was Number 17500 and the late set was Number 18930. Model 80 was number 20900 and Model 82 was 21000. The story was repeated in the cabinets of the three sets. The Model 84 cabinet was an arch 19 inches high, with plain pilasters. Models 80 and 82 have carved figures (ropes,) one with the arch and the other with the rounded top. The later Model 84, as tabulated in the service manual, wore the same old cabinet. Perhaps it had become the low-end set and was not worth upgrading when a new series (the Nineties Series) was to be introduced.

Some present-day collectors have a Model 84 radio with a cabinet having plain pilasters that continue up around the arch, Figure 64. A



Figure 64. *Two Model-84 Radios. Kent started building his compacts with the Model 84 Early, the one without the outlines on the curved portion of the case. The Late set was dressed a little more to give easy identification.*

collector might have changed the cabinet, but another explanation might better fit the circumstances. Perhaps a second cabinet was chosen for the Late Model 84 by the factory and fitted to the then-current production. It could even have been offered to dealers. Later radios in the Atwater Kent line (Models 310 and 510) were offered with a choice of cabinets. An enterprising dealer could also have ordered spare cabinets and used them when his customers wanted the fancier radio while the factory was shipping the upgraded Model 84 Radios.

MODEL 80

Model 80 was the simplest of the new series; another five-tube superheterodyne circuit for processing the signals, with a type-80 rectifier in the power supply. Kent's engineers changed the mixer and the IF tubes from type 24A in the H-chassis and the Early Model 84 to type 35. The change did not alter the stage gain for these two stages and therefore might be considered of questionable value. The reason for the change came from a different requirement, namely volume control by the user. In Model 84 the volume control operated directly on the IF signal. Other models in the Eighties Series (Model 82) incorporated automatic volume control (Kent called it "control") and therefore needed the remote-control characteristic of the type 35 to alter the gain.

In Model 80 the user had to provide his own control by using the volume-control potentiometer. Model 80 did not incorporate any automatic volume control. The user volume control was a potentiometer connected in the cathode returns of the mixer, the IF amplifier and the oscillator. The remote cut-off characteristic of the type-35 tube made for smooth and effective control in the mixer, and especially in the amplifier. The connection of the potentiometer in the cathode of the oscillator might have provided some volume control, but its greater effect was to modify the oscillator's grid bias and consequently the mixer's conversion efficiency. Volume control by means of oscillator cathode bias was not carried forward into later sets. The IF in the Model 80 series, like that in the H chassis was 130 kHz. This was a low frequency by comparison to those that were used later in Atwater Kent radios.

In 1931, the technology for manufacturing stable, sharply-defined bandwidths had not been developed, so IF frequencies below 200 kHz were favored. As a further indication of the lack of IF experience, the Model 80 again used a simple parallel-resonant circuit for the plate load of the mixer. The double-tuned transformer was only used to couple the IF amplifier to the detector. The bandwidth of the Model 80 was not as sharp as that of the H chassis and was probably marginal when the Model 80 was used in a large city such as New York.

MODEL 82

Although the Model 82 compact superheterodyne did not appear to be a large technical change from Model 80, it did incorporate what was at the time a major improvement. It was the first radio in the entire Kent line with automatic volume control (AVC).

The chassis of Model 82 was of the same size and layout as Model 80 with the addition of another tube, a type 24A that provided control of the amplification of the mixer and the IF amplifier. The effect of the control tube was two-fold; it allowed the listener to change the level of sound, and it compensated for changes in signal. As with Model 80, the volume of sound that the listener wanted to hear from his radio could be set by rotating the volume-control potentiometer. Movement of its arm adjusted the cathode voltage of the control tube. If no other change took place, the plate voltage of the control tube responded to that change and, in turn, set the grid voltages on the mixer and IF amplifier grids and thereby the amplification of those stages.

The second function, compensating for changes in incoming-signal level, was a very desirable feature for a radio to have. Variations in the behavior of the transmission path caused changes in the output volume that could range from blasting loudness to nearly non-hearable whispers.

Where the listener was well within the immediate coverage of a station, the volume did not change very much, but listening to distant stations was not comfortable family fare. AVC changed that and brought radio a lot further into the living room, out of the hobby class.

With the exception of the control tube, the other functions of the Model 82 were similar to Model 80. The sensitivity and audio output were the same, and like Model 80 it used the 130-kHz IF and Double Spot Tuning to attenuate the image.

Model 82 was the first Atwater Kent set to reflect the influence of decorated-gothic styling in its cabinet. When it was properly set off in the furnishings of a 1930s living room it was, indeed, handsome. The cabinet was similar in construction and size to Model 80 but a little different in appearance because the rounded top had been made a little more pointed to suggest the gothic-arch style. It was the same size and shape as Model 84 but was not so plain. The service manual called it a compact with carved twist pilasters. Again, the speaker was mounted above the chassis in the arch. At the time of its introduction, the radio was said to have an excellent tone. In today's competition with stereo components it does not win, but there are many collectors who prefer its sound to that produced by our modern near-perfect reproducers.

Atwater Kent had become familiar, in the days of the metal-cased radios, with the several different power sources that served his customers. Much of the country, particularly in the mid-west, used 25-Hertz alternating current. For those listeners, the Kent radio line supplied a nearly identical set to the one that was operated on 60 Hertz. The main difference was in the power transformer, which was specifically designed for service on 25-Hertz lines. In some radios of the Atwater Kent line, there were minor variations in the size of the filter condensers or in the field resistance of the loud speaker, but these were not found in the Eighties Series. The letter "F" was appended to the Model number to identify the 25-Hertz set.

In some cities, particularly New York, power distribution was accomplished with direct current. Kent had supplied dc sets from the beginning of the house-power days (Model 41). When he brought out the superheterodynes, he continued to offer a dc version, designated with the letter "D" following the model number. The circuits of the dc superheterodynes were quite different from their corresponding ac versions. One reason was because the source voltage (110 volts dc) had to be used for plate voltages instead of the 250 volts typical of the output of the power supplies in the Model 82. The second reason concerned the use of tubes with high-current, 2½-volt filaments. If used in a series string, these tubes would have been unnecessarily wasteful of electricity, as compared with the 6-volt tubes that had been developed for automobile-radio service.

Model 82D incorporated type-36 tetrodes for the mixer, the IF amplifier and the second detector. The circuits were very similar to Model 82. A type-37 triode was used in the 82D for the oscillator instead of the type-27 used in Model 82, but here the near similarity ended. The control tube of Model 82 was not included in Model 82D, so the AVC function was not available.

User volume control was accomplished by a means of a potentiometer in the grid circuit of the IF amplifier. Rotating the shaft permitted the user to feed as much signal through the set as he wanted for comfortable listening, but he was not regulating the audio directly. In this set he was changing the IF signal. The relatively low IF (130 kHz) could be controlled reasonably well by the potentiometer. At that frequency, stray capacity did not shunt the resistor to the point where it became ineffective.

The output tube of Model 82, a type 47, was not used in Model 82D. Instead, a type-33 pentode was substituted. Even with that tube the lower plate and screen voltages in the set would not have provided enough overall amplification. The problem was solved when another tube was added, an audio amplifier, a type 37. It was connected between the detector and the grid circuit of the output tube. The tone-control circuit was connected to its grid by providing a switch to shunt one of the three condensers to ground.

One more control circuit was added to the Model 82D, but it did not control the operation of the set in a normal way. It was a 75-watt bulb connected in series with an electrolytic filter condenser. The electrolytic condenser served to filter the incoming power as well as acting as a polarity sensor. If the set was plugged into the dc mains with incorrect polarity, the lamp lighted. When the connection was correct, the lamp stayed cold and its filament put only a small (negligible) resistance in series with the filter. When the set was plugged in with wrong polarity and turned on (and the lamp was lighted) perhaps as much as one-third of an ampere flowed through the condenser. With a wet electrolytic, the condenser acted as a forward-biased rectifier and survived. A dry electrolytic, which might be used today as a replacement, would probably need a reversed diode across it to operate the lamp and to protect the condenser.

MODELS 83 AND 85

For several years Atwater Kent had been building his business and his reputation on console-style radios. He had watched his metal-box sets incorporated in console radios, from desks to imposing furniture.

He had produced Model 55 and 60 chassis which did not have metal boxes but instead had small panels to set off the dial and the knobs. Their consoles provided a wide opening that was closed when the chassis was installed in the cabinet. With the Seventies Series, Kent got into the radio-furniture business and provided a choice of consoles, along with a choice of chassis, so that his dealers could customize Atwater Kent radios for their customers.

This successful experience led to developing a line of consoles for the Eighties Series. There were two approaches; lower-priced sets that used circuits copied directly from the compacts, and higher-priced, more deluxe consoles that used circuitry especially designed for each console. Models 83 and 85 were the lower-priced sets and Model 86, 87 and 89 were the higher-priced models. This segment will review Models 83 and 85.

The first compact superheterodyne chassis that was copied was Model 80. It became Model 83 by being spread out on a full-sized stamped one-piece chassis (20 inches wide by 12 inches front to back and one inch deep) similar to that first used with Model 55. For Model 55, the chassis was only 10 inches from front to back. For the Seventies Series, the chassis size was increased to 12 inches front to back. At that time, however, Atwater Kent's presses were size-limited, so the H-chassis and the others in the Seventies Series were formed from two pieces, each about half the total width. The two pieces were riveted together to form a single assembly unit. With the Eighties Series, the new presses were used to make the larger one-piece chassis.

Model 83 (and the Model 80) had one stage of IF, an amplifying second detector and a single output tube. The mixer, IF and second detector were type-35 tetrodes and the output was a type-47 pentode. A type-27 triode was used as the local oscillator.

The second console with a circuit identical to its corresponding compact was Model 85, the duplicate of Model 82. The consequent difference between Model 83 and Model 85 was the AVC capability that resulted from the inclusion of the control tube, a type-24A tetrode. This improved the capability of Model 85 in the same way that it had done for Model 82. Both Model 83 and Model 85 were produced in the "F" version for the 25-Hertz market, and Model 85 was also produced in a Q version for battery use.

Models 83 and 85 used the same loudspeaker that had been used in Models 80 and 82, a nine-inch electrodynamic. In the console versions the cabinet would have generated more boominess than in the compacts, but that sound was popular with the customers of that day. Atwater Kent seems to have been a little tentative about the market, since Models 83 and 85 were neither the compacts that might have been too novel for his clientele nor the consoles that were the quality products of his line. He

must have found a market for these sets because some have survived to be part of present-day collections.

MODEL 86

In reviewing earlier sets in the Eighties Series, circuits in two consoles that were identical to two compacts were considered (Models 80 and 83 and Models 82 and 85). The strange element of those sets was not the common circuitry but the mechanical conversion from the larger chassis to the smaller one. Other users of Atwater Kent's manufactured compact chassis put them into consoles directly. Kent could have done this too but did not take this step. Did he use the large chassis with the console because that was his tradition? Was this association of chassis to console somehow related to his sense of quality? A clue to this question would be interesting, especially because in later sets he did use the same chassis in both the compact and the console. In those cases he did assign two different model numbers to the chassis, so that they related to the cabinet as well as to the chassis.

Model 86 (and Model 86F) never had a corresponding compact configuration, in part, because it required more front-to-back space behind its dial. This was the result of having an RF amplifier, which is how its circuit differed from earlier sets in the Eighties Series. It used the circuit developed for the front end of the H chassis of the Seventies Series. To assure enough image rejection, four resonant RF circuits were used and they required the four-gang tuning condenser and the greater space. With a tuning condenser similar to those used in the Seventies Series, and the attachment of the dial that had been used earlier, the larger chassis used for Models 83 and 85 was needed.

Model 86 used type-35 tubes for the RF amplifier, the mixer, and the IF amplifier. The use of the type 35 was necessary because the set incorporated AVC and had to have the remote cut-off tetrodes to obtain control. The tubes used for the second detector and the control tube were type-24A tetrodes to assure enough gain. A type-27 tube was used for the local oscillator, and the output tube was a type 47, which was resistance coupled to the detector and had the tone condensers across its grid.

The user of the Model 86 controlled the volume of the set by means of a potentiometer in the potential-divider chain of the power supply. It provided gain control by varying the cathode voltage of the control tube. AVC was generated by connecting the grid of the control tube to the cathode of the second detector, where the rectified IF signal changed the control tube bias as the signal varied. AVC was effected by connecting the plate of the control tube directly to the grids of the IF and the RF amplifiers and the mixer.

As the incoming signal increased, the grid voltage on the control tube increased, and the plate voltage decreased. That made the grids of the amplifiers and the mixer more negative (with respect to their cathodes) and reduced their amplification, thereby canceling, in part, the original increase in signal strength. The output power of this radio was moderate because only one tube, operated in Class-A service, was used to drive the speaker. The set was sensitive because of its RF amplifier so it did not require a long antenna. The Model 86 was well suited to the interests of a middle-income family.

MODELS 87, 87D

The program content of many broadcasting stations in the early 1930s included some very fine music, and some listeners wanted more volume to fill their listening areas with more sound than was produced by radios that used only single output tubes to drive their loudspeakers. The Atwater Kent line of radios had used dual output tubes in the TRF days but those were triodes. The type-45 triodes that had been used in the Sixties and Seventies Series (except for the Model 66) were relatively ineffective by comparison to the type-47 pentode because of their lower amplification.

The radios in the Eighties Series all used type-47 tubes for output-power generation, and through designing and building the sets, Kent's engineers gained experience in using the pentode. They used their experience and the standard RCA push-pull tube circuit to design Model 87 with two output tubes, and thereby satisfy the customer demand for higher output from the newest set.

Atwater Kent's engineers changed the resistance-coupled output circuit of the Model 86 to a transformer-coupled circuit similar to what had been used in the Seventies Series, but with the parameters for two type-47 pentode tubes. The circuit did not alter the bias values from the simpler circuit; it still ran in Class A. The advantage was a higher output, a little more than twice the single-tube value, but with much reduced second-harmonic distortion.

The audio input was supplied by a type-27 triode amplifier, coupled through an input transformer with a grounded, center-tapped secondary. The type-47 tubes were operated in Class A by being self-biased with a resistor in the filament return to chassis ground; they provided a maximum of five watts output.

Model 87 used a 12-inch loudspeaker with an open-back cabinet. Its tone had a strong peak in the bass register near 200 Hertz. Tone control was accomplished by switching one of four condensers across the input-transformer secondary, but this muffled the high register while doing nothing for the bass register. In the days of Model 87 and some of the

later sets, a flat audio spectrum was unheard (and unheard of) in the living rooms of most listeners. The accentuated middle-bass range had become the excitement of the early thirties. That electric-sound was highly desired.

The circuit functions of Model 87 were an RF amplifier, a mixer and an IF amplifier, all using type-35 tubes. The second detector and the local oscillator used type-27 triodes. The audio tubes were one type 27 and two type-47 tubes (described above.)

The user volume control in Model 87 was a little different from the other radios in the Eighties Series. The radio did not have AVC and therefore did not have a control tube. Volume control was achieved by using a potentiometer in the power-supply-resistor chain to change the cathode voltages on the RF and the IF-amplifier tubes. The uncommon part of the control circuit was the connection of the oscillator-tube cathode in parallel with the amplifiers. Changing the oscillator-cathode voltage would have changed the strength of the oscillator signal and therefore the conversion ratio. This would have had some effect on the overall volume, but it was not a good enough method to have been carried forward into other Atwater Kent-radio designs.

Model 87D, a direct-current version of this radio, was put on the market shortly after the Eighties Series was introduced. In the main, the circuits of Model 87D were the same as those of Model 87, but there were some significant differences. Because the energy to operate the set came directly from the 110-volt house power, there was no transformer and rectifier. The field coil of the loudspeaker was not part of the power-supply filter, but instead was connected directly across the power line. The output stage of the Model 87D used two type-33 pentode tubes instead of the type 47s in Model 87. To make up the change in gain, the first-audio amplifier was changed from a triode to a type-38 pentode. This type-38 pentode might have also been used in the output stage instead of the two type 33s that were installed, but it could not deliver as much undistorted power with the reduced plate and screen voltages that were necessary in the dc set.

Like Model 87, the 87D had an RF amplifier, a mixer and an IF amplifier that all used tetrodes, but instead of type-35 tubes it used type-36 tubes. This was not a remote-cutoff tube, so the gain-control system in Model 87D was different. A potentiometer, part of a dual unit, was used to alter the screen voltages of these three stages. The second part of the dual potentiometer was connected across the input coil of the first RF transformer, with its tap connected to ground. It acted as a "losser" in the antenna circuit. The operating conditions of the three stages were such that full signal reduction was not easily accomplished, so the antenna losser added the necessary reduction.

The second detector in Model 87D was another type-36 tetrode instead of the type-27 triode of the Model 87. All high-gain tubes were used in the set, largely because under the operating conditions even they were only just adequate. The line-up of Model 87 would not have been sufficient. The oscillator in Model 87D was a triode, type 37. All the tubes, except the output tubes, had 6-volt filaments. The type-33 output tubes had 2-volt filaments paralleled with resistors to bring their current requirement to 0.3 ampere. This made practical the series connection of the filament string (40 volts) with a suitable dropping resistor across the power line.

MODEL 89

Model 89 was the top-of-the-line radio in the Eighties Series of Atwater Kent's offering for the 1931 holiday season. It included the best features of all the other superheterodynes in the series, so a review gives an interesting picture of the Kent design-group's activity. A brief comparison of the circuits in Model 89 with their counterparts in the other sets in the 80 series tells the technical historian much about how Kent's designers did their work. Model 89 could be considered a synthesis of the best answers they chose for each of the potential design questions.

To start: In reviewing the tubes that were selected for accomplishing the functions in the set, the conditions under which the tubes were operated, and the required stage performance (amplification, conversion, spectrum shaping,) the tubes that were chosen seem almost classic. As examples, the operating conditions and the expected gains of the selected tubes are almost exactly those found in the RCA tube handbooks for the times.

A quick review of the stages shows the interesting choices. Starting at the antenna, the compacts had shown that the Double Spot Tuning method was not as good a way to remove the effect of image sensitivity as using directly-tuned resonant circuits. Model 89 used a tunable, resonant circuit to change the low impedance caused by a short antenna into a high-impedance resonant circuit suitable for keeping unwanted signals out of the antenna. It utilized a second resonant circuit to feed the grid of the RF amplifier tube, which also carried the AVC voltage to the grid. The output of the RF amplifier was fed to a low-impedance point on the coil of the third tuned circuit. This combination of RF circuits and a type-35 amplifier was almost exactly the one that had been used in Model 86. Altogether, in terms of image suppression and RF antenna-circuit isolation, it was a better method than that used in Model 87.

The AVC control tube and its circuitry were taken almost directly from Model 86. The difference was that in Model 89 the grid of the mixer was included in the AVC feed from the control tube. The user volume control in Model 89 was different from all the earlier sets. It

was a potentiometer connected between the second detector stage and the first audio amplifier, the system used on nearly all of our modern radios. Kent's engineers had come to realize that the AVC would take care of signal levels in the RF and IF amplifiers so that the user only had to change the detected audio level.

The interstage IF transformers in Model 89 had also come from Model 86. RCA had recommended that for IF amplifiers that used AVC, the double-tuned transformers were superior to simple IF-tuned resonators. The control of coupling between the primary and the secondary of the double-tuned transformer extended the flat portion of the band-pass without reducing the sharpness of the skirts, and made possible a more uniform detected audio spectrum.

The later Model 89, like the Model 86, included a switch around one bleeder resistor in the voltage-divider chain. It permitted the user to short the resistor out or leave it in. The effect was to change the cathode voltages and thus the gains of the RF and IF amplifiers and the mixer. A strong local signal could be reduced so that the set operated about the same as it did with a weaker signal.

Model 89 was also produced in the "F" version for 25-Hertz power service, and in a "P" version that included a record player in the console cabinet. The pickup for the record player was a magnetic unit, made by RCA for Atwater Kent, connected through a switch to the low end of the volume-control potentiometer. When its arm was rotated in the counterclockwise direction it fed more of the record-player signal to the audio system. When the radio-phonograph switch was in the Phono position the grid of the control tube was grounded so that the RF and IF amplifiers and the mixer were nearly inoperative.

MODEL 81

Model 81 was the first automobile radio that Atwater Kent produced for general sale. It was part of the Eighties Series but it was not a superheterodyne. Instead it was a seven-tube Tuned-Radio-Frequency set powered by batteries. Model 81 seems to indicate, in very general terms, the size of Atwater Kent's engineering group in 1931. The work of preparing both the first compact design (Model 84 Early) and adapting the Model H chassis to the Eighties Series big-chassis design (Model 85 console) took all the staff. Later in the year the work on the second phase of both the compact designs and the big-chassis-set designs was finished. At about the time that Model 89, the top-of-the-line set in the Eighties Series, was being completed, the design of the automobile radio was initiated.

Model 81 was produced in three versions, Models 81, 81-B and 81-C. All three had the same chassis and circuitry for processing signals, and the same power supply, three B batteries and four C batteries. The differences were in the way the sets were packaged in their metal containers. Model 81 included the B and the C batteries in the main container of the radio. The radio was to be mounted under the floor of the automobile, with control cables routed up to a control head on the steering column.

Models 81-B and C included the C batteries in the main container, but put the three 45-volt B batteries in separate containers, to be mounted separately in the car. Model 81-B was to be mounted under the dashboard. Model 81-C was to be mounted under the floor, through a hole cut in the floor. The control head was the same for all three sets but the interconnecting cables, both mechanical and electrical, were cut to different lengths to accommodate the location of the radio. All three sets used the same speaker, enclosed in a round metal housing for mounting under the dashboard.

The Model 81 radio had three stages of RF amplification using three type-36 tetrode tubes. The last tuned RF transformer fed a type-37 triode connected as a power detector. A second radio-frequency signal was fed from the plate of the third RF amplifier through a blocking condenser to the grid of the control tube, another type-37 triode. An increase in the amplitude of that signal caused the plate voltage of the control tube and the grid voltages of the RF amplifiers to go more negative. The RF gain was thereby reduced, providing some automatic gain control (AVC) action. Volume in the Model 81 was controlled by altering the bias on the control tube with a potentiometer mounted in the control head. This acted similarly to the AVC action on the plate voltage of the control tube and the grid voltages of the RF amplifiers.

The output of the power detector was fed to the pair of type-38 output pentodes by means of a phase-dividing transformer. Their outputs were combined in the output transformer housed with the loudspeaker. The type-38 output tubes were operated in Class A, drawing about 12 mA per tube. With the RF-amplifier tubes and the screen grids of the output tubes the depletion rate for the 135-volt B battery supply would have been about 30 mA. Good batteries would have lasted about 60 hours, making the operation of Model 81 very expensive.

MODELS 82Q, 84Q, 85Q

The battery-operated radios in the Eighties Series were designated by the number of the ac radio from which they were derived and the letter "Q". The case and the chassis in each case corresponded to the ac-set number. The circuits within were very similar, a seven tube superheterodyne with one RF and one IF amplifier. The amplifiers, the mixer and the

second detector were type-32 tubes. The first audio amplifier and the oscillator were type-30 tubes. The output tube was a type 33.

Models 82Q and 85Q came out in early and late versions. The differences among the sets were of two kinds. One had to do with the chassis size. Model 85Q was a console, while the others were compacts. The other difference had to do with feeding and bypassing the amplifier and mixer stages. Model 84Q controlled its volume by using a potentiometer in the IF chain. The others used a potentiometer to tap part of the detector output to feed the grid of the audio amplifier.

All of the Q radios in the Eighties Series used the Type-J loudspeaker. It was a permanent-magnet, electro-dynamic (sic) cone-in-frame device that carried four horse-shoe magnets on the frame opposite the cone. The magnetic structure was arranged to present a radial field in a gap of almost identical characteristics to those of the regular electro-dynamic speakers then in current use. The output transformer for the set was mounted on the side of the magnet structure.

THE NINETIES SERIES

Atwater Kent's radios of the Nineties Series are not as easily grouped into a single time period as the Atwater Kent radios were previously. In some ways, this series appears to have been an upgrade to the Eighties Series, particularly intended to put new-looking radios in the dealers' showrooms without having to go through a major redesign and new-production cycle in the factory. In other ways this series appears to be a bridge to the next set of radios, the first of the three-number sets. The approximate time of this group of radios was early 1932.

Two of the radios in the Nineties Series were upgrades of the corresponding models in the Eighties Series. Nearly no engineering or factory modification was required for them. They were compact Models 90 and 92. Two others were minor upgrades, console Model 96 and 99. Model 94 was another console taken from the Eighties Series but with a sharply different configuration from Model 84. It was almost like Model 96 but did not have a control tube. One set, Model 93, was not a complete radio. It was a short-wave converter, to be used with a radio like Model 92 to broaden the received spectrum to cover the short waves of the early 1930s. One more radio, Model 91, was a partial copy of the corresponding radio from the earlier series. Its circuit was, however, very different because it was a superheterodyne. The new series did not include upgrades for battery radios (the "Q" versions) or the dc radios (the "D" versions) that were part of the earlier series.

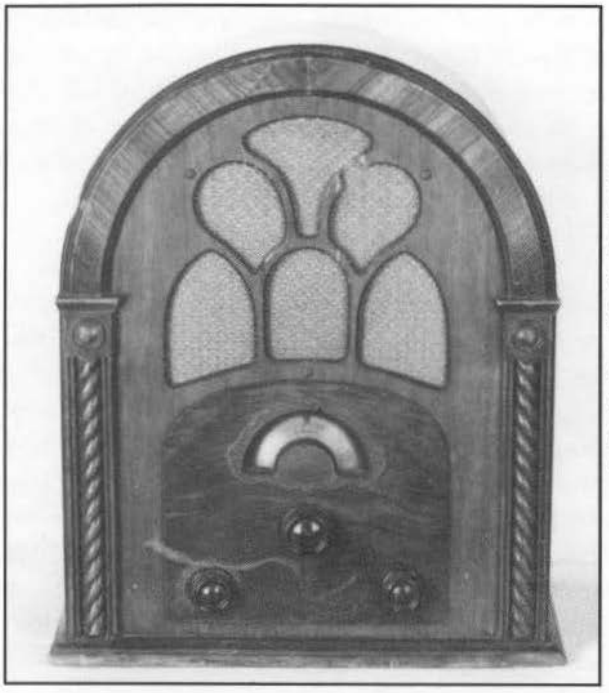


Figure 65. *Model 90. The model year after the introduction of the Eighties Series needed a more decorative appearance. This set shows the difference. Inside it offered significant improvements, including automatic gain control.*

MODEL 90

Model 90, Figure 65, was the set in the Nineties Series that corresponded to Model 80 in the earlier series, but it had an important improvement. Model 90 used an RF amplifier whose circuit was closely related to Model 86 and Model 87. It was not identical to the RF amplifiers in those sets, because its coils were constructed differently and the tapped coil that had connected to the plate of the RF amplifier in the earlier sets was replaced by a simpler, untapped resonant circuit.

Model 90 eliminated the Double-Spot tuning of the earlier compacts by using four tuning condensers, as did the Models 86, 87, and 89. The user controlled the volume that the set delivered by adjusting a potentiometer in the voltage-divider chain of the power supply. Adjusting the arm changed the cathode voltages of the RF amplifier, the mixer, the oscillator and the IF amplifier. No AVC was offered on this radio. The other user control was a switch that connected one of two (or no) condensers across the grid circuit of the output tube. The cabinet for this radio was very similar to that of Model 80, a round-topped arch. The Model 90 was also made available for 25-Hertz power; it carried the "F" designation. In the later (second) type of the Model 90 the grid returns for the RF amplifier, the mixer and the IF amplifier were connected to the resistor

that returned the detector tube grid to ground. Because the cathode of the second detector was relatively fixed, its grid circuit acted like a grid-leak detector and became negative with an increasing IF signal. The result was increased bias on the amplifiers with consequently reduced gain. The action was similar to the diode action in a much later tube. It was one way that AVC was achieved.

MODEL 92

A compact radio that provided AVC was needed in the Nineties Series. This need was met by the later Model 90, but it was also offered on Model 92 before the later sets were built. This was not a difficult design task. The example of adding the control tube and its circuitry had been put together in the expansion of Model 80 into Model 82. The addition of the RF amplifier was the basis of Model 90, and combining these two functions became the design of Model 92. The difference between Model 92 and the earlier sets was the way that the AVC voltage was derived. In this set, the output from the second IF transformer was fed to the grid of the control tube. An increase in IF signal increased the control-tube current and reduced its plate voltage. This was the same as increasing the bias on the RF and IF amplifiers and the mixer, and consequently reducing the total gain.

Another function was added to Model 92, a sensitivity switch. It worked like the one in Model 89 where it changed the voltages in the power supply divider. It increased the AVC standing bias when it shorted one of the divider resistors. In Model 92, the user volume control was a potentiometer between the output of the IF amplifier and the grid of the second detector, where it tapped the IF signal to reduce the level of audio detection. Because it was connected to a tap in the IF coil secondary, it did not affect the action of the AVC circuit.

MODELS 94, 94 F

Model 94 corresponded to Model 83 of the earlier series of the consoles with the big chassis. Its circuitry was very much like the early Model 90, although its RF coils were solenoids in form and were shielded. The RF stage of Model 94 used the four-gang tuning condenser that was characteristic of the big chassis from the Model H, in the Seventies Series. In the early version of the set, the user volume control was the only means of adjusting the sensitivity and loudness of the radio. It was a variable resistor in the voltage divider in the power supply and served to alter the cathode voltage of the oscillator, the mixer and the RF and IF amplifiers.

The later version of the set used the same method of producing AVC as was added to Model 92, i.e., connecting the grid returns of the amplifiers and the detector together and tying them to ground through a load resistor. The detected IF signal developed a bias voltage, which acted to maintain a constant value at the detector even if the input signal varied substantially.

As with many of the other radios in the Atwater Kent product line Model 92 had a corresponding 25-Hertz set, Model 92F. It differed mainly in the power transformer and in including more power-supply filtering.

MODEL 96

Model 96 was the radio that incorporated all the good features that Kent's experience and developmental skills made available for the part of the American buying public that wanted an up-to-date console. It used an RF amplifier and four tuned circuits to isolate the possibility of radiating interference and to remove the annoyance of the image-frequency sensitivity. It used double-tuned IF transformers for the IF amplifier, and provided volume control by bridging the last IF coil with a potentiometer to feed the second detector.

The radio also included an AVC circuit similar to those in the previous sets. The AVC signal was taken from the high end of the last IF coil (the same coil that the audio signal came from) and was fed to the grid of the control tube where it was detected and used to change the plate voltage of that tube. That voltage was connected to the grids of the RF amplifier, the mixer and the IF amplifier to control their bias and their gain.

Model 96 was the first Atwater Kent radio to provide a tuning indicator. The device was visual, that is, it indicated to the user's eye when the station was properly tuned. Atwater Kent called it "Tonebeam." It consisted of a vertical glass-enclosed column that was filled with neon and contained two electrodes, a long one about the height of the column and a short one at the base. When the Tonebeam was operating it was illuminated part way up and remained dark above the glow. The height of the glowing column was a function of the voltage difference between the two electrodes. One of the electrodes was connected to a dropping resistor that fed the amplifier plates from the B+ supply. The changing plate current in the RF and IF-amplifier tubes changed the drop through the resistor and the Tonebeam electrode. The other electrode was connected to a potentiometer in the voltage divider of the main power supply. The user adjusted the arm to set the glow at the bottom of the tube when there was no incoming signal. More about the Tonebeam and its circuitry can be found in *Modern Radio Servicing*, Alfred Ghirardi, Radio and Technical Publishing Co., New York, 1935, pages 488 and 489.

Model 96 went through three versions as well as being produced for 25-Hertz use. It was similar to Model 86 but it had one subtle change; the first IF transformer was bridged by a resistor in Model 96. The double-tuned IF transformers of that time had not used over-coupling to broaden their pass-band, and therefore their sharp tuning limited the high-frequency audio response of the set. While that was not bad for some listeners, it did need correction. The resistor reduced the "Q" of the transformer and thereby broadened the response.

The stage functions were the same in each of the versions of Model 96. Only minor changes were made, such as the biasing of the Tonebeam and the exact action of the sensitivity switch, which was changed in the several versions. All of the Model 96 radios used the type-24A tube for the second detector. It was biased to act as a power detector and also performed as the first audio amplifier. All the Model 96 sets used the single type-47 pentode to provide the audio output.

The Model 96 was assembled with its front panel attached to the main chassis. The fan dial and tuning knob, the volume and tone controls, and the sensitivity control were part of the panel. To the right of the fan dial and opposite the volume control knob the Tonebeam was set into the embossed panel so that the glowing column was viewed through a decorative vertical slot.

MODEL 99

Analyzing the Model 99 in Atwater Kent's line of radios brings a major characteristic of radio design in the early 1930s into sharp focus. The key point is that work that had been successfully done in making earlier radios was saved to become the basis of further work. To a technical person this does not seem greatly significant, but most of the people who benefit from specialized technical endeavor do not realize how much prior experience is embodied in a present product.

Model 99, Figure 66, illustrates the point nicely. It was the set where three major developments in radio design and manufacturing came together. The Seventies Series produced an excellent large stamped-steel chassis with very complex installed circuitry, easy-to-assemble and easy-to-test factory methods. Included in the Seventies Series was the first superheterodyne but it was not a major positive experience.

The Eighties Series developed the superheterodyne starting with the unsatisfactory first Model 84 with its Double-Spot Tuning and inadequate IF amplifier. The RF amplifier was reintroduced and the control tube and AVC were introduced. The little chassis was tried and the big chassis was used to build a radio that was less than Kent's image. All the good features were combined in Model 89.



Figure 66. *Model 99. Kent's console superheterodynes were imposing. This one had all the features of the others and a signal-strength indicator, the vertical slot on the right of the tuning dial.*

The Nineties Series used the good experience of the Eighties Series in such concepts as compacts, but removed some of the negative features. RF amplifiers were included in all sets in the series and the IF transformers were improved. The Nineties Series introduced the new feature that the general user of high-quality radios found very desirable, a visual tuning indicator, the Tonebeam.

Combining the best of all three series resulted in Model 99. It had the sensitivity and sharpness of the improved RF and IF amplifier designs from sets in the Nineties Series, the AVC and user control of volume and tone from the Eighties Series, and enough power from the sets in the Seventies and the Eighties Series to satisfy the most discriminating listener.

The chassis of Model 99 was only a step away from Model 89, and like that set, was available with a phonograph included in the top of the console. While Model 99 with its ten tubes was the best Atwater Kent radio of its time, there were other improvements that would come along. They would be built on the fine performance of Model 99 just as it had benefited from its predecessors.

MODEL 93

In 1932 radio in the home had become a regular part of family life. The classic radio shows (programs) that historians and collectors play today are curiosities, especially to today's young people. They are matters of rewarding recollection to many of our older folks who listened to the shows when radio was new. At the time of the Nineties Series, radio drama attracted many fans. Nearby radio stations were the main outlets, but there was still a large segment of the audience who wanted to hear their programs from afar. Distance still called to the radio listener.

Regular programming was mainly presented on the broadcast band. Almost all radios that were bought for the American home tuned that band exclusively. One strong reason was that, at that time, band-switching

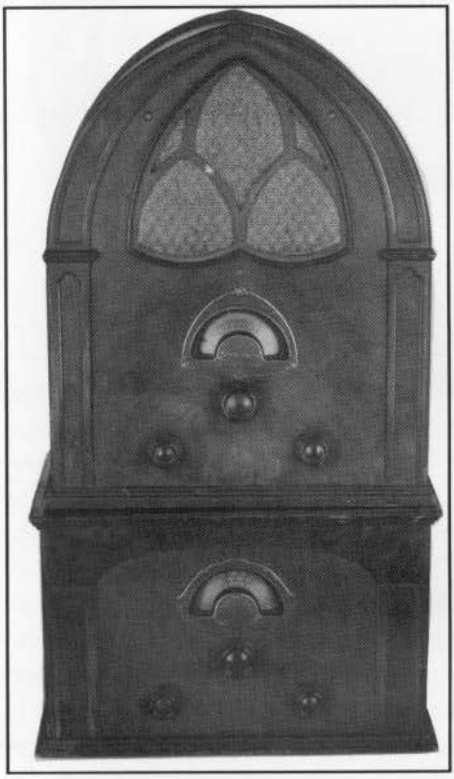


Figure 67. *Model 93 with Model 84. This combination was an effective short-wave receiver. The lower unit was the converter that produced a 1-MHz IF signal for the receiver (the upper unit).*

that would make listening to the short waves easy had not yet become reliable and long-lived enough for general use. Laboratory and commercial equipment could be built but not at costs reasonable for the home market. None of the Atwater Kent receivers produced up to 1932 included short-wave reception.

The technology of short-wave radios of that time was to use sets of plug-in coils that were specific for each band. The National Company produced receivers that came with several sets of coils for the short-wave bands, as did others such as Hammarlund-Roberts. These sets were not what today is called user-friendly. RCA produced a short-wave converter that also used plug-in coils. Kent recognized the market and set about a solution to the user problem. He came out with Model 93.

Model 93 was a three-tube short-wave converter that used band switching to cover the frequencies above the broadcast band. Its circuit was a very basic superheterodyne. The first tube was a type-27 oscillator that generated a signal 1.0 MHz above the desired input frequency. The second tube was a type 24A which acted as a mixer for the input signal from the antenna and the oscillator signal. The third tube was another type 27 that acted as an IF amplifier, operating at the difference frequency of 1.0 MHz. Three bands were required to cover the entire spectrum; 1.5 to 3.5 MHz, 3.5 to 8.5 MHz, and 8.5 to 19.0 MHz.

Two electrical features of the converter were different from the way that Kent's broadcast superheterodynes had been designed. One was that a standard three-gang condenser was used for tuning when only two sections were connected, one for the oscillator and the other for the mixer input from the antenna. The other feature was the means of coupling the oscillator signal into the mixer. The oscillator coils and the antenna coils were carefully laid out on their forms and the forms precisely located in the chassis, so that the amount of coupling was different but suitable for each band. The variation of coupling between the coils solely by position-controlled induction suggests that the design department had not forgotten the Model 50 RF circuitry.

The Model 93 converter was packaged in a flat-topped cabinet ten inches high with a footprint that matched the compact radios in the Eighties and Nineties Series. The intention was to place the compact radio on top of the converter to make a complete short-wave set, Figure 67. To make this arrangement convenient to operate, a power receptacle was mounted on the rear apron of the converter chassis into which the power cord for the compact was to be plugged. Main power was fed through the converter so that when only the compact radio was to be used it could be turned on independently.

When the converter was not to be used, the antenna signal was fed directly to the compact radio. When the converter was powered, the

antenna signal was lifted from the feed to the compact radio, switched to the mixer, and the output from the 1.0 MHz amplifier switched to the antenna of the compact radio. This function was controlled by a ganged-switch in the converter.

MODELS 91, 91B, 91C

Model 91, the second automobile radio built by Atwater Kent, emphasizes the story of Kent's limited engineering staff. The difference between the early Model 84 and subsequent sets showed that his technical people had to schedule their designs because there were not enough people to work on all the radios in a series. Model 91 again illustrates this point.

Comparing Model 91 to its predecessor, Model 81, leads to the conjecture that the market called for an automobile radio and that the limited staff couldn't design a superheterodyne during their work on the Eighties Series ac radios. The Part Numbers suggest that they also couldn't do the mechanical design of the B-battery boxes in time for the first release of Model 81. After the first series was on the market, Kent's people finished the mechanical design, but they still couldn't get to the electrical design of Model 91. When the designs of the Nineties Series radios were under way, the change of the electrical design from a TRF in Model 81 to a superheterodyne in Model 91 was undertaken.

Some of the design of Model 91 was carried over from the old set. The old audio circuits and the control-tube operation were the basis of the new design. The superheterodyne circuit of Model 92 provided the remainder of Model 91's electrical design. The mechanical design of the electrical circuitry was unique in the automobile set and it is quite probable that substantial circuit verification was required. This was especially true with regard to the effects of an automobile environment on stability.

Model 91 was a nine-tube battery set built into the same containers as Model 81, and it used the same set of B and C batteries. The functions were an RF and an IF amplifier, plus a mixer using type-36 tetrodes, a second detector with a control tube, and an audio amplifier plus the local oscillator, using type-37 triodes and two type-38 output tubes connected as a Class A push-pull amplifier. As with the earlier set, the volume control was by way of a bias adjustment on the control tube, actuated by a potentiometer in the control head fastened to the steering column.

Battery life was even shorter in Model 91 than in the previous set. In trying to imagine how the set was used in a 1933 automobile several thoughts offer themselves. First, the radio was expensive and the car in which it was installed must have been expensive as well. Second the car would not have been used for long-range commuting so the programs

that it received would have been more the Sunday drive kind. This idea could be extended to have the radio entertain at picnics and other family gatherings held in the out-of-doors. One summer season would have been as long as one set of batteries would have lasted, so a part of the annual maintenance of the car would have been replacement of the batteries by the radio sales and service shop. Altogether this would have been expensive, so it seems that Model 91 was a radio for the upper-middle class, the customers who liked Kent's console radios.

Chapter 16

ATWATER KENT USES THREE NUMBERS

THE 1932 SERIES

Model 99 used the last of the two-number identifications. Perhaps the radio market looked a lot smaller in the early 1920s so that a two-digit system for model identification seemed practical. Perhaps Kent didn't look that far ahead or perhaps he didn't feel the numbers meant as much to him as they have turned out to mean to the collectors of his radios. The easy way to extend the system would have been to add a third number to the set, and this is what he did.

The difficulty comes when one tries to figure out what, if anything, the code of the numbers stands for. In the old system the first number indicated the series or group and the second number indicated the placement of a radio in a given group. The first number was roughly progressive with time and complexity. The second number had a vague relation to the kind of power used by the set. DC sets were 41, 51, 61, but that fell apart with 81 and 91.

When the three-digit identification scheme was put into place an entirely different characteristic was important; the number of tubes in the set. There might have been a technical reason for this identification, but it looks much more like the marketing side of the factory made the choice. The third digit specified the number of tubes for single numbers up to nine. For Model 228, the number 8 identified the set as having eight tubes.

Radio sets with ten tubes were identified with 0 as the last digit. The model numbers for sets with 11 and 12 tubes used two terminal digits that were the same as the number of tubes. If the last two digits in the Model number were 1 and 2 as in Model 812, the number of tubes would be 12. Kent did not make a radio that had more than 12 tubes. Moreover, he did not make as many 12-tube sets as there were single digits available. There was no Model 712 and no Model 912.

Collectors have tried to fit the first digit and the second digit to some characteristic like cabinet style or year of production or performance features, but so far, no success. The mystery has always been what the first and first two numbers meant. Complexity? Maturity? Function?

Order of assignment from a list? None of these has broken the code!

The remaining segments of this review consider the sets in the order of the years when they were released. Within that frame, the sets are separated into compacts and consoles and further ordered by complexity. Accompanying this issue of the *AWA Review*, but on two separate lists, are tabulations of the full set of Atwater Kent radios. On one the radios are listed by year and type. On the second list the order is numeric by Model Number.

Model 567 and Model 228 were the first compacts to be designated with the three-number scheme. They came immediately after the compacts in the Nineties Series. The first console to follow the Nineties Series was Model 188. Some things are clear from the model number and some are totally obscure. Tube count was clear in all cases but one. However if the radio was built for dc operation (D version) or was to be used with batteries (Q version) the number of tubes was usually one less than indicated by the model number. In those cases, the circuit had been derived from the ac version so the Model number of the 60-Hz set was used as the designator, even though the actual tube count varied because there was no rectifier.

The obscurity came from the designation of the first two compacts and the console mentioned above. There doesn't seem to be any correlation between the numbers, the circuits, the styles or the tube types. Kent's service literature gave lists of the sets that were current at the time of issue but there was no comprehensive list. Kent must have thought the radios would need immediate (infant) service but after they were grown the service need would disappear. Did he think they would die? Or age without degeneration?

MODEL 567

Models 567 and 567F are referenced in the Atwater Kent Service Manual folder dated July, 1932 as new compact models. The data for them is given as the "same as used in—" Models 90 and 90F. The Model 567 compact (and the next in line, Model 228) were mid-year introductions. Their electrical design was carried over from their immediate predecessors but they were restyled to appeal as new. The compacts in the Nineties Series were good performers so there was no strong reason to upgrade for performance as there had been with the first Model 84.

No new features nor functions that could be easily incorporated in the small size of the compact had become available in mid-1932. Reusing the Nineties Design and manufacturing capability was a cost effective way to operate, especially in the early depression. Kent's design effort was better spent on circuit development for the bigger sets, with the

hope that improvements to them could be added to the compacts later. He had that experience with the RF amplifier stage that was not in the Eighties Series compacts but was added to the Nineties Series and carried over to the Models 228 and 567.

Kent could have added a control tube to Model 567 and offered AVC on that set. That would have made it the same as Model 228. The result would have been to have no radio on the low-end of the product line. Model 567 was the fourth member of the progressing low-end-of-line sets. The first was early Model 84 with the type-24A tubes. Then came Model 80, followed by Model 90. Model 567 followed as number four but it was not to be the last.

Model 567's engineers did not improve the transformers in the RF amplifier and did not add a double-tuned IF transformer in the output of the mixer. The overall performance of the radio was satisfactory but not of a quality that polished the Atwater Kent nameplate. In the increasingly tough competition of the thirties this set did not hold its own against other brands such as Philco.

MODEL 228

Model 228, Figure 68, was the next compact radio in the Atwater Kent line. It came out in the middle of 1932. It was also to be a part of the offering in the Holiday season at the end of that year. Model 228 was made in three other versions, the D for dc power lines, the F for 25-Hertz service, and the Q which was the battery-operated set.

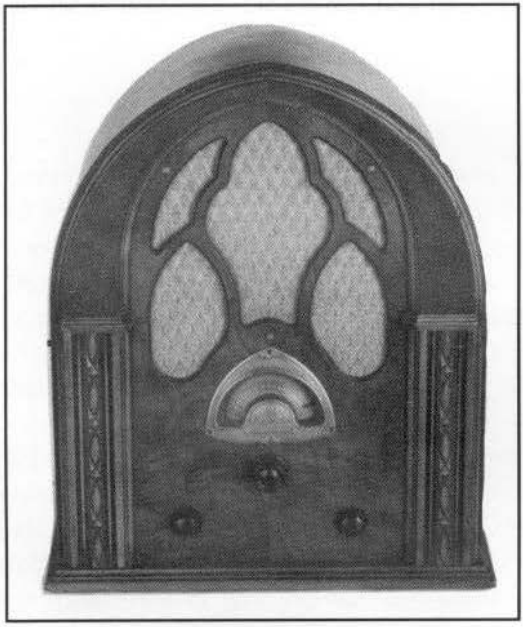


Figure 68. *Model 228. This compact was the third in the flow of progress from the Eighties Series and the Nineties Series. It was better dressed but did not add any performance features.*

Model 228 was electrically identical to Model 92, and the F versions of both models were similarly identical. The set used three type-35 tubes for the RF and the IF amplifiers and the mixer. The output tube was a type 47 directly fed from the second detector, a type 24A. The radio had AVC using a type-27 control tube and also used the type-27 tube as the local oscillator.

The D and Q versions were identical to Models 82 D and Q. Model 228D was only a six-tube set. It did not have an RF amplifier and did not use a control tube. Type-36 tubes were substituted for the type-35s in the mixer and the IF amplifier. A third type-36 was used as the second detector. Two type-37 tubes were used in the set, one as an audio amplifier and the other as the local oscillator. A type-33 output tube was used in place of the type 47. Model 228Q was the same as Model 82Q. The set was a seven-tube superheterodyne that used type-32 tetrodes for first and second detectors and for the RF and IF amplifiers. Type-30 triodes were used for the local oscillator and for the first audio amplifier. The output tube was a type-33 tetrode. The sound reproducer was a type-J, permanent-magnet, electro-dynamic loud-speaker.

The cabinet of Model 228 was a little finer in decoration than the earlier sets and its arch had a curve less severe than the gothic arches but not as circular as Model 90. The sensitivity switch, a toggle, was mounted on the side of the cabinet. Model 228 constituted only a minor change from the radios in the Nineties Series. It was brought out because a newer set was needed for the market. Model 228 was upgraded for merchandising reasons (appearance) rather than to implement an improvement in technology or performance.

MODEL 188

Model 188 was the first set in a new era of circuit design for Atwater Kent's engineers. The manufacturers of vacuum tubes had designed and produced a new pair of triple-grid (pentode) amplifiers to replace the tetrodes that had been included in the designs since Model 55 started the screen-grid age. One of the new tubes was type 57, a sharp cutoff tube with very high amplification capability, to be used for detection and general amplification. It replaced the type 24A in the Atwater Kent line. The other triple-grid tube was type 58, the remote cutoff pentode that complemented the type 57 and replaced the type 35 for Atwater Kent's designers. Type 58 was designed for controlled amplification of radio-frequency signals. It was also effective for mixer applications.

Model 188 was, essentially, a Model 86 radio (or a Model 96 without the Tonebeam tuning indicator) for which the type-58 tubes were substituted for type-35 tubes in the RF and IF amplifiers and in the mixer. The

increased available amplification from the new tubes required two changes in the circuitry. The inter stage RF transformer was modified to include windings for the oscillator so that the input to the mixer grid was made up of both the oscillator signal and the amplified RF signal. Both of the double-tuned IF transformers were bridged with resistors, in part to reduce the overall amplification of the IF signal and also to improve the response spectrum.

At about the same time as the triple-grid amplifiers were brought out, an improved triode, type 56, replaced the workhorse type 27. While its use may not have resulted in great improvements in Kent's designs, other users welcomed the new tube. It had a much higher capability to amplify high radio frequencies. It shared a second advantage with the pentodes, a reduced filament-current requirement. They each needed only one ampere where their predecessors needed 1.75 amperes.

In Model 188, the control tube and the oscillator were changed to type-56 tubes. The AVC function was similar to the arrangement in Model 86 where the plate of the control tube was directly fed to the grid circuits of the amplifiers and the mixer. In Model 188 the feed was through a resistor that acted to provide some isolation. The higher-gain type 56 produced a slightly larger AVC voltage. The oscillator in Model 188 was modified to reduce its grid feed back signal by tapping down on the oscillator resonant circuit. That maintained the oscillator frequency stability by keeping the grid signal from becoming excessive. The oscillator coil was contained on the same form as the input RF coil for the mixer so that there was enough injection by the transformer action to replace the cathode connection that had been used earlier.

In the Model 188, early type, the second detector became a type 57, replacing the type 24A. The detector circuit was similar to that in Model 96 where the IF signal for control detection was taken from the top of the second IF transformer secondary. The signal that was fed to the type-57 grid for audio detection was taken from a potentiometer tapped down on that coil. The detector was a power detector where the cathode was biased to nearly cut the tube off and a positive-going half-wave of the IF signal caused the detector current to rise in accordance with its modulation.

One other important change took place with Model 188. The mechanical construction of the set was improved. A new chassis layout was devised and it would become the new way to build sets. A new variable tuning condenser was designed and installed. This new condenser design was to become the basis for the other sets in this series. The differences would only be the tube punch-outs and the attachments for small parts under the chassis.

After production had been established, a second type Model 188 was brought out. Its functions and performance were not changed from the first type but minor improvements were incorporated. The second detector was changed to a new tube, type 55, a double-diode, triode. One diode was used for AVC and was fed through a condenser from the plate of the IF amplifier. The AVC voltage was developed across the diode load resistor and fed through an isolating resistor to the grid circuits if the RF and IF amplifiers and the mixer.

The second diode of the detector was fed from the output of the IF transformer through another condenser. The audio signal was developed across a potentiometer whose arm was fed to the grid of the triode section of the type-55 tube. The plate of the audio-amplifier triode was transformer coupled to the type-47 output tube.

The third change was to replace the type-56 triode tube that had been used for control in the first type Model 188 with a type-57 pentode in the second-type set. The pentode was used for an entirely new function: Silencing. Atwater Kent used the term, "Silencing," to mean suppression of the audio output while tuning between stations. The plate of the silencing tube was fed from the power supply in parallel with the first audio amplifier (the triode in the type-55 tube). The grid of the silencing tube was fed AVC voltage directly. A small signal, such as inter-station noise, did not generate much AVC voltage, so the silencing tube conducted strongly, thereby decreasing its plate voltage. The plate of the audio amplifier was also depressed so the tube did not amplify and no signal was fed to the output. Conversely, a large signal caused a large AVC voltage and cut the silencing tube off. It therefore had no effect on the audio signal. The function of the silencing function was to remove the noise the set made when it was tuned from one desired station to another.

MODEL 260

Model 260 was the first of the radios bearing three-digit numbers to have ten tubes. It therefore used the zero as the third digit. It was not Kent's first ten tube set; he had put out Model 99 in the previous year. Kent's engineers made several important improvements in going from Model 99 to Model 260. The most important improvement was to add a new feature, the Silencing tube. This change was made in the Third Type. It was a means of reducing the noise volume of the radio when it was tuned from one station to another. To make the silencing tube work, another change was incorporated in the Third Type. It used the type-55 double-diode-amplifier tube that RCA had added to the line of new tubes that included types 56, 57 and 58. It performed three functions in the Model 260, Third Type: audio detector, AVC detector, and first audio amplifier.

To change the silencing level, a control was made available on the front panel. It replaced the range switch that had been used in the First and Second Types. Changing the control changed the screen voltage on the type-57 silencing tube which changed its plate voltage. The plate of the silencing tube was fed in parallel with the plate of the audio amplifying section of the detector-first amplifier tube. Changing the silencing level altered the plate voltage of both tubes and effectively reduced or increased the audio amplification.

In the first two types of Model 260 there was no silencing tube. They used a type-56 triode as the second detector. It was connected differently than had been done in other, earlier superheterodynes that Kent had produced. In the First and Second Types of Model 260, the high end of the last IF transformer secondary was connected to the cathode of the detector. The low end of the secondary was connected through a large resistor to the grid. The resistor acted as both the audio and the control loads.

The action was akin to a simple diode detector but was, in effect, reversed. The control signal appeared on the cathode and because the grid voltage did not vary, changed the plate voltage of the triode. The plate of the detector/control tube was connected through their input transformers to the grids of the IF amplifiers, the mixer and the RF amplifier, all type-58 tubes. AVC was thus provided. The audio signal was taken from the grid of the detector and fed through the volume control potentiometer to the first audio amplifier, a type-56 triode. Its plate produced an amplified audio signal that was fed to the input transformer of the output stage.

Another important improvement in Model 260 (all types) was the additional (second) IF amplifier. Up to the time of Model 260, only one IF amplifier was used in Kent's superheterodynes (except Model H). Because of the revised AVC detection in Model 260, a slightly larger signal was needed at the detector. The extra IF stage provided the increase. Model 260 was offered with the Tonebeam for an indication of proper tuning. It was connected in the same way as it had been in earlier sets. The plate current in the amplifiers was sensed to determine the height of the glow in the tube. The silencing circuit (Model 260 3rd Type) did not affect the AVC and the Tonebeam. It only changed the audio output. The set was meant to be operated with the silencing circuit quieting the output as soon as the station was detuned. As the set was tuned to the next station, the Tonebeam would indicate when the next station was of sufficient strength to bring up the audio. The action was much like the muting function found on present-day FM radios.

The big-chassis superheterodyne consoles built just before Model 260 must have exhibited a small remaining-image response. Relatively large signals at the image frequency (twice the IF, 260 kHz above the wanted signal) might have leaked through if the incoming signal was weak and the AVC calling for substantial amplification. Therefore, more RF filtering was built into Model 260. For listeners in areas where the stations were all moderate in signal level, there would have been no reason for the change, however, this set was one of Atwater Kent's best offerings so the image response had to be suppressed. To do this, the tuning condenser in Model 260 was changed to five gangs, four at the incoming frequency and one for the local oscillator. The resulting distribution of the four resonant RF circuits was two between the antenna and the grid of the RF amplifier and two between that amplifier and the mixer. In Model 260, First Type, the early set, single coil forms were used for each pair of resonant coils. The coils coupled with each other inside their shielded cans and therefore acted much like double-tuned transformers.

In the Model 260, First and Second Types, the double-tuned transformer, made up of the two resonant coils between the amplifier and the mixer, was retained. In the Third Type, the resonant coils between the antenna and the input of the RF amplifier were wound on individual forms and were separately shielded. The variation in antenna characteristics that was typical of the antennas that different listeners installed (including a very short wire in a situation where the desired signals were strong) would have nullified the effectiveness of an input transformer. The separate resonant circuit in the antenna circuit was more effective in image rejection and at the same time would not have upset the resonant circuit in the grid of the RF amplifier.

The other circuits in Model 260 were similar to those used earlier. The output was a pair of type-47 tubes, operated in Class A. The local oscillator was a type-56 tube, coupled into the cathode of the mixer. The earlier two types of the radio had the same sensitivity switches that had been used on other sets.

The cabinet of the Model 260 was a low-boy in form with short legs. The panel for the set was a simulated-wood, steel panel with the Tonebeam centered below the fan dial. The tuning knob and the volume control flanked the dial with the silencing and tone knobs further apart. Model 260 was produced in the F version for 25-Hertz power in all three types.

THE LATE 1932 SERIES

MODEL 627, 627F

Model 627 continued the practice of including the available improvements in the newest Atwater Kent product line. It included all the new technical features of Model 246 and added two. These were an RF amplifier and inductive injection of the local oscillator signal. Model 627 was a single-band radio (broadcast only) with the extra gain of the RF amplifier. To provide tuning and image rejection, the tuning condenser was made up of four gangs; two for resonators between the antenna and the RF amplifier, one for the resonator between the amplifier and the mixer and one for the local oscillator.

Model 627 was also part of another line of designs. It was essentially an upgraded Model 92. The type-35 tetrodes used in Model 92's RF, mixer and IF stages were replaced in Model 627 with type-58 pentodes. The new tubes were used on the old IF, 130 kHz. The new type-55 double-diode, triode replaced the type-24A second detector and the type-27 control tube to make the AVC function operate directly from one of the diodes in the type-55 tube. The audio detector used the second diode to develop the signal across the potentiometer. The tap on the potentiometer was fed to the grid of the triode section of the detector tube. The signal at the plate was coupled through a resistance/condenser network to the grid of the type-47 output tube. This part of the circuit was taken directly from Model 92.

Model 627 was the first compact chassis to be equipped with inductive local-oscillator signal injection. It was accomplished by winding two sets of coils on one coil form. The coils involved were four; the RF tuning coil for the grid of the mixer, with its primary winding excited by the plate of the RF amplifier, and the resonator coil connected to the grid of the local oscillator and feed back coil excited by the plate of that tube. The physical size of the form, the coils and their spacing were designed to provide reasonably constant injection over the broadcast band. The purpose of this method was to put both signals (incoming and local) on the same element of the mixer tube. It was thought that better conversion gain would thereby be achieved. Whether this method was better than using the cathode for the injection of the local signal was never decided for Atwater Kent's designs, since both were used and both were set aside when the pentagrid converter became available.

Some of the older power systems in the United States were still operating at 25 Hertz. Nearby were 60-Hertz systems, but the interconnection of many systems into a grid was not the operating mode in 1932. That

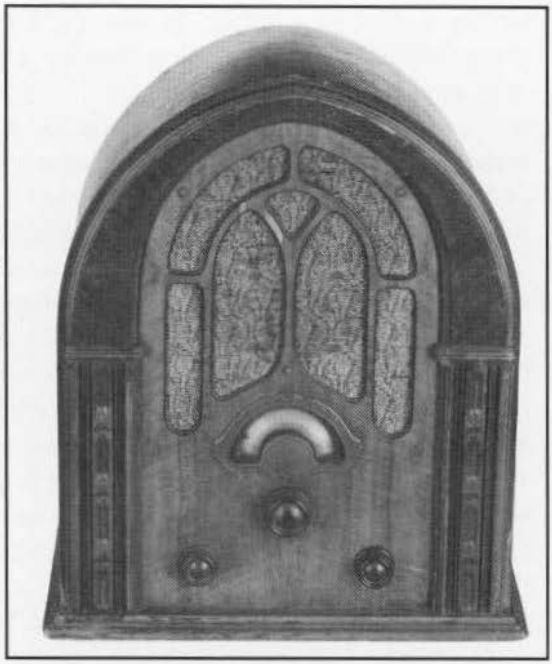


Figure 69. *Model 627. The cathedral style served well for a middle-cost radio. This set was much like Model 228 but replaced the tetrodes with pentodes to give the same performance with one less tube.*

would have to wait until the 25-Hertz alternators were replaced and the necessary power lines were erected over many miles of user areas.

Kent did not concern himself with the maturing of primary power systems. Instead he continued to produce an F version of his popular radios. Model 627 was such a set. By late 1932 the differences between the 60-Hertz version and the 25-Hertz version were so small that the Service Manual did not print separate diagrams, voltage tables or parts lists. Model 627 offered another feature, the sensitivity switch. Its function was to reduce the sensitivity of the radios for listeners who listened to strong stations. It worked by exposing or shorting a bias resistor in the common cathode circuit of the RF and IF amplifiers. When the resistor was in the circuit, the bias was increased, the remote cutoff tubes reduced their amplification and the signal was reduced. The switch was a toggle mounted in the curve of the left side of the cabinet. The fan dial and the cabinet were very similar to Model 92. The decoration was a little fancier but the style was clearly Atwater Kent.

MODEL 558, F, D, Q

Compact Model 558 was a good example of Atwater Kent's engineers using a design more than once. The radio was Model 627 with an added function, silencing. Kent used the name, "Silencing," for an automatic reduction of a radio's volume of sound when it was tuned from one

strong station to another. In late 1932 selecting different stations was quite desirable because the networks and many local stations offered very attractive programs. The dialing-in process was comparatively easy but it could also be noisy, especially when a big station was located between the old and new choice. The silencing function reduced the annoyance of blasting the unwanted station into the living room during tuning. The means of accomplishing the silencing function was to put the plate circuit of a no-signal (silent) tube in parallel with the plate of the audio amplifier triode in the second detector. The plate current through the silencing was controlled by the AVC signal, and between stations the AVC voltage became less negative so the silencing tube turned on. Its plate voltage dropped and took the audio-amplifier plate with it. That reduced the audio output substantially. At the same time the amplification of the RF and IF stages increased so the silencing function was offset to some degree by the amplifiers. A potentiometer was connected to the screen of the silencer tube, a type-57 pentode, to give the listener some control over the degree of silencing.

Model 558F was the same set as the Model 558 except for the power transformer. The practice in the factory of producing the same set for both 25- and 60-Hertz alternating current systems had a history that went back to Models 36 and 37.

The D and the Q versions of Model 558 are illustrative of another facet of Atwater Kent factory practice in 1932. It would appear that customers for the large consoles, powered from direct-current sources, either dc mains or batteries, were not strongly interested in the finer differences between radio models. Perhaps the measure was cabinet selection and appearance accompanied by adequate reception rather than superior circuit performance. Because there was no strong benefit in bringing out two electrically different direct-current radio chassis, the dc versions of Models 558 and 469 were one chassis, even though Model 469 was a console. The chassis was marked with the proper identification for the entire radio, including cabinet and chassis. The chassis of the Model 558D Compact was the same chassis as Model 469D Console, and similarly, the Model 558Q chassis was identical to the one in the Model 469Q console. The direct-current powered chassis for these two sets are reviewed under Model 469.

MODEL 469, F, D, Q

Each year Atwater Kent produced several console model radios along with the compact sets. This review has presented the compacts first and then the consoles as a total series for each year. The order of presentation

is the increase in complexity of the radio circuitry. That complexity relates strongly to the number of tubes in each set. Therefore, the presentation in each series follows the last digit in the model numbers as they came out, year by year.

Model 469 was the next radio of increasing functional capability that was re-engineered to use pentodes instead of tetrodes in the RF and IF amplifiers and the mixer. This set followed logically from the Model 188, along a path that is remarkably similar to the paths of radios in the 80 series and in the 90 series. As indicated by the last digit in the model number, another tube was added to the then-current circuitry of Model 188 to make Model 469.

The added tube in Model 469 was an another output tube, type 47. In effect, this addition was very similar to the change from Model 96 to Model 99. The second tube was operated in Class A so the maximum output power was approximately doubled. The pair were transformer-coupled on the input side and operated in push-pull.

This was not the only difference between Model 188 and Model 469. In the First Type 469, the second detector was changed from the type-57 pentode of Model 188 to a type-56 triode. The audio input was taken from a tap on the secondary winding of the last IF transformer via a potentiometer which served as the volume control. The reduction in gain caused by the change in tube types was compensated for by the inter stage audio transformer and the additional output tube.

Model 469, First Type, included a control tube, type 56. Its input came from a resistor-condenser bridge across the secondary of the second IF transformer. Its function and circuitry were similar to that in Model 188. The output of the control tube was the AVC signal. It was fed from the plate of the control tube through an attenuating resistor to the grids of the three type-58 pentodes (RF and IF amplifiers and mixer.)

The oscillator in Model 469 was a type-56 triode, but the circuit was not the same as in Model 188. In Model 469 the injection was by use of a winding on the oscillator transformer in series with the cathode of the mixer. This had become the commonly used method for sets with tetrodes. The mechanical design of the RF circuitry did not include the closely located coils of Model 188. Instead the RF coils and the oscillator coils were contained in separate shields under the chassis.

Model 469 included the Tonebeam visual-tuning indicator that had appeared on Models 96 and 99. Its circuit was slightly simpler than in the earlier sets but the action was the same. Increasing the AVC bias on the amplifiers and the mixer reduced their current and allowed the drop across the bleeder resistors to diminish. This, in effect, raised the input voltage to the short electrode of the Tonebeam and raised the glow up the long electrode. The maximum AVC voltage occurred at best tuning, as did the highest glow in the Tonebeam tube.



Figure 70. *Model 469. The success of the Nineties Series led to this set. It was based on the big chassis and traced directly back to the H Chassis.*

The Second Type Model 469 was brought out shortly after production started. The type-57 detector tube was replaced by the type-55, double-diode triode. This design change, which was common to Models 188, 469, and 260, took place at about the same time as RCA made the type-55 detector/amplifier available for general use. The replacement of the type-57 detector with the type 55 made more effective demodulation possible and eliminated the type-56 control triode.

In Model 469, Second Type, as in Model 188, Second Type, the type-57 tube formerly used as the detector was given a new function, the Silencing tube. The silencing function was installed in sets that might have been sold late in 1932 but was a feature for radios in 1933. It had good sales appeal but was limited in its application since it was only incorporated in the big-chassis consoles.

Model 469 was also produced in a "D" version for use on dc power mains. Its functions were the same as Model 469, Second Type except for the power supply. The tubes it used were equipped with six-volt filaments and connected in series. Their characteristics were similar to the 2½-volt tubes in the Model 469. The RF and IF amplifiers and the mixer used type-39 tubes. The second detector was a type 85 and the output tubes were type 38s. The oscillator tube was type 37 and the Silencing tube was a type 36. The Model 469D radio was constructed on a smaller chassis than had been used in the earlier consoles. It was approximately nine by 15 inches.

These substitutions made the Model 469D functionally similar to Model 469 and satisfactory to the general listener who had dc power in his home. The dc set did not have the overall sensitivity and lacked the maximum power output of the ac version. But for homes that were served with dc distribution the signal level were moderate to high, and the radio was not noticeably different from the Model 469, Second Type, running off the ac mains.

Model 469Q was derived from Model 469, but the relationship is more instructive in design variation than in similarity. To start, the third digit in the model number for a Q set was usually one higher than the number of tubes in the set because the rectifier was not used. (It was equal to the count in the AC sets.) Model 469Q had nine tubes and was therefore the exception to the practice. It also added an IF-amplifier stage to the Model 469 design to add one tube, and combined the oscillator with the mixer to remove one tube. It added an audio driver tube that evened the count but produced a very different functional design. (Keeping count of the number of tubes in the "Q" version was even less satisfactory when it is remembered that the Model 469Q was identical to the Model 558Q chassis.)

The second IF amplifier was needed because the battery tubes, type-34 pentodes, were not as effective as the type-58 tubes in the ac version. Combining the mixer and the local oscillator in one type-32 tube was a standard design, but it was not generally used because it was not nearly as effective as the separate-tube oscillator for conversion efficiency and stability over the broadcast band. The trade-off was against battery power.

The audio-output circuitry was clearly designed to limit the B-battery drain, while providing for enough output power to justify the expensive radio with its console style in a living room. Two type-30 triodes were used as the "push-push" output stage. They had 180 volts of B-battery on their plates with 15 volts of grid bias. That operated them as a modified Class B amplifier. For small inputs, the output tubes drew very little current and because of some crossover the circuit was quite linear. With large input signals the Class B output stage required a driver. A transformer-coupled type-30 audio amplifier provided the drive. It was connected between the type-32 second-detector tetrode and the final amplifier stage. The maximum output power would have been a little less than one watt, with distortion near 10%. Model 469Q was equipped with a control stage to provide AVC. The tube was a type-30 triode fed from the secondary of the last IF transformer. Its plate was connected though isolating resistors to the grids of the RF and IF amplifiers.

The chassis of Model 469Q was the same as that of the D version, 15 inches wide by nine inches deep. The punched holes for sockets and

hardware were different from the D version but the general layout was the same. This chassis was very different from the older style big chassis used for Model 469. Newer factory wiring techniques, combined with smaller-sized piece parts, made the new chassis cheaper to manufacture and use. It also made servicing easier by reducing the handling problems associated with the big chassis.

MODEL 480

Model 480 was the first complete short-wave radio set that Atwater Kent produced. He had offered a short-wave tuner, Model 93, but that did not have the features that were expected from a complete, band-switched radio. Model 480 was the same as the Model 469, either the First or Second type, with three changes. The most important was the substitution of switched-RF and oscillator coils for the earlier broadcast coils. The second was adding a second IF amplifier, and the third was changing the IF frequency to 472.5 kHz.

The choice of the intermediate frequency in a superheterodyne was strongly influenced by the highest expected incoming frequency. An IF of five percent or more of the highest signal frequency permitted good image suppression without having to employ extreme means. For Model 480's highest band (8.5 to 21.2 MHz) Kent's engineers chose 472.5 kHz. This was a little more than five percent and therefore did not require difficult circuit engineering. The amplification in the front-end circuitry of this radio was a little lower than in Model 469 so a second IF amplifier stage was used to make up the difference.

The electrical front end of the radio had to be made up of coils and condensers that resonated over the specified range of the radio. With typical coils and condensers each band covered a range of a little more than 2½ times. That resulted in three short-wave bands. The lowest short-wave band covered 1.5 to 4 MHz, the medium short-wave band went from 3.6 to 9.2 MHz and the range of the highest short-wave band was 8.5 to 21.2 MHz. Altogether there were five bands, the other two being two broadcast bands.

The standard four-gang condenser was used. Tuning for the lower two short-wave bands was not a problem with that condenser, but the highest band was limited by the condenser's minimum capacitance. The RF coils were connected with wafer switches. Between the RF amplifier output and the input of the mixer, the circuit was a simple parallel-resonant tank. The plate and the grid were switched on two separate wafers. Between the antenna and the RF amplifier input the circuit was a transformer with an untuned antenna-coupling coil for its primary. For each short-wave band, the primary was the secondary of the next

higher band. The tuning condenser stayed with the grid of the RF amplifier. For the broadcast band, a tuned antenna transformer was switched between the antenna and the broadcast-band tuning coil. This provided extra selectivity but whether it was needed is questionable. The coil switching for the oscillator was similar to that at the input. The oscillator used a feedback winding for each band. That coil was the resonating coil for the next higher band, except on the top band where it was a dedicated winding. The oscillator was a type-56 tube whose output was fed to the cathode of the mixer tube.

Model 480 was built with two IF stages that used double-tuned IF transformers. The IF tubes, the mixer and the RF amplifier were all type-58 tubes. All of these were controlled with AVC provided by a type-56 control triode. The AVC control signal for the control tube was taken from the top of the primary of the last IF transformer. For audio a tap on the secondary of that transformer fed IF to the volume control potentiometer and enabled the listener to change the amount of audio detection provided by the type-56 power detector and thereby obtain control of the radio's volume.

The output of the set was provided by push-pull type-47 tubes fed through a transformer from the plate of the detector. Tone-control condensers could be switched across the transformer secondary. Tuning on this radio was indicated by a "Tonebeam." It was connected to use the change in plate current of the mixer, the first IF amplifier and the RF amplifier as the control for the height of the glow. The range switch also had two wafers arranged to add bias to the cathodes of the amplifier tubes and the mixer in the first broadcast position of the range switch. The intention was to reduce the overall amplification of the radio when it was used on local stations. The function was like that of the sensitivity switch of other Atwater Kent high-priced radios.

MODEL 612

Model 612, Figure 71, was the first of Atwater Kent's twelve-tube radio sets. It brought together all the features that had been developed up to late 1932 and provided additional audio- power capacity. The list of features included an RF amplifier using a type-58 tube with four tuned circuits, a type-58 mixer with cathode coupling from a type-56 local oscillator, two IF stages using type-58 tubes, a type-55 second detector with one diode for AVC and the other for audio, a first-audio amplifier using the triode in the type-55 second-detector tube, a Tonebeam visual-tuning indicator, a silencer tube using a type-57 pentode, a new audio-output system using three type-46 tubes, and a heavier power



Figure 71. *Model 612. Kent's customers included people who were ready to pay for the best. This set with 12 active tubes and high output power was well accepted.*

supply using two type-83 rectifiers. The circuits for all the functions, except the output amplifiers and the power supply, were almost identical to those in the Model 260 3rd Type, and others that used 2½-volt pentodes. The output amplifier was a pair of type-46 tetrodes operated with their screen grids tied to their plates. The tubes in that configuration drew nearly no current at zero grid bias and therefore made excellent Class B amplifiers. They were transformer coupled so that, with sufficient driving power, they worked in the push-push mode with only one tube drawing current in any audio half-cycle.

The type-46 tubes had been designed for this service by RCA with the idea that much more power could be obtained from a pair (and at much higher efficiency) than could be delivered with Class A tubes. The benefit was not, however, without price. The output pair of type-46 tubes had to be driven by a source capable of supplying their input-power requirements. This meant that a third type-46 tube had to be added to provide sufficient drive. The driver type-46 tube was connected in its high gain, Class A mode (screen grid connected to the signal grid.) The driver put about the same amount of power into the output stage as earlier sets that had used a single type 47 delivered to their loud speakers. The maximum output from the system in the Model 612 was nearly 16 watts.

This amount of output and the amount of driving power placed a much higher power requirement on the main power supply. Not only did it have to deliver more power, but it had to regulate better under the peak audio demands for current that are characteristic of Class B output amplifiers. The type-80 high-vacuum rectifier tube that was used in earlier sets had an internal voltage drop that was both excessive and current sensitive. The type-83 tube was a mercury-vapor rectifier with a smaller, nearly constant drop over a wide current range, and therefore much better suited to supplying power for Class B audio amplifiers. Two of these tubes were used for the power supply.

The total power requirements for Model 612 were greater than could be economically handled by a single high-voltage secondary on the power transformer. Atwater Kent's engineers split the load and used two secondaries, each with its own rectifier; in effect, two power supplies. One secondary served the three type-46 tubes. The other provided the power for the rest of the radio. By separating the Class B stage all the way back to the primary of the power transformer, maximum isolation of the sensitive AVC and tuning circuits was obtained.

MODEL 812

Model 812, Figure 72, was almost the same radio electrically as Model 612. It was built on the big chassis but the console cabinet was very different. It had been designed as a striking piece of furniture to enhance the living-room decor of the high-middle stratum of American homes. Kent did not spare quality in producing the radio, and it did not curtail features even though it was introduced during the depression. Model 612 had used the less-expensive cabinet that was also used with Model 260, but Model 812 made no compromises. Its cabinet was specifically designed to complement the deluxe-chassis design. The goal for this set was to appeal to those who only accepted the best.

Model 812 went a step beyond Model 612 in power-supply design. Atwater Kent's engineers decided to push the type-46 tubes in the output of the radio to their maximum ratings by raising the plate voltage fed to them. They therefore decided against a single power transformer as was used in Model 612. Instead they split the load and designed two power transformers, each with its own rectifier, to make two power supplies. As with Model 612, one power supply served the three type-46 tubes, but at an increased voltage of more than 350 volts at the plates of the output tubes. The other supply provided power for the rest of the radio. Again, the separation of the Class B stage from the rest of the system provided a maximum isolation of the sensitive AVC and tuning circuits. Model 812 was capable of an output power of more than twenty watts.



Figure 72. *Model 812. Most collectors consider this radio the epitome of Kent's production. It used two power transformers, one for the radio and the other to power the output stage. It also had two loudspeakers.*
Photo: Alan Douglas

The two speakers were designed specifically for that set, both in terms of power handling and for the field resistance and the current that they took from the high-voltage power supply.

The rest of the circuitry in Model 812 was the same as that of Model 612. The IF frequency was still 130 kHz. Therefore the front end had to have the four resonant tuned circuits that assured quiet operation. The set used the silencing tube to eliminate inter-station noise and included the Tonebeam for accurate tuning. Altogether, Model 812 marked a high point in the radio development of the early 1930s. It was also the best radio that Atwater Kent had produced up to 1934.

Chapter 17

THE 1933 SERIES

By 1933 the role of radio in the homes of America had become a stable part of family life. Although not every family had a radio and not all the radios were of the latest design, enough listeners were tuning-in and enough broadcasters were offering programs to generate a public demand for instruments and programs that was clear and emphatic. Earlier radios had been offered in a variety of enclosures from which two major styles had emerged, the console and the table radio. The style of the console had been changed somewhat from the Nineties Series to provide a smooth visual flow from top to bottom, uninterrupted by decorative turned legs.

The floor-model, big-chassis console offered higher power and better sound along with its attractive décor. It quickly became a complement of living-room furniture. However, there was another segment of the market, which also wanted the console style but with a less powerful radio. For these customers, the radio manufacturers used the chassis designed for the compact style, with a slightly larger loudspeaker for better tone, and put them into a less fancy console of similar style.

The table model, called the "compact" by Atwater Kent, was characterized by incorporating the loudspeaker into the radio. It was mounted in the enclosure above the radio chassis. The result was a style with a little more height than width in the cabinet. The first examples of the new compact style had rounded and arched tops where the speaker was enclosed. Variations in the detailed renderings led to the "flat tops," with rounded shoulders and gentle curves. The chassis for the compact style was generally large enough to accommodate a power transformer, a large tuning condenser and six or more tubes. The size and style of the compact quickly developed to reflect two major influences. Technical improvements permitted the chassis to get smaller with still-adequate performance, and price reduction enabled the manufacturers to stay in business. The result was another line, the midgets.

By 1933 the popularity of radio sets extended beyond the home into the automobile. The market at that time was small but it had great potential. While the design of a car radio was quite different from that of a home

radio such as the compact, it was very much within the product manufacturing capabilities of the large radio manufacturers, especially Atwater Kent.

With the introduction of the Seventies Series, Atwater Kent got into the console-cabinet business. The consoles that were used for that series were not manufactured by Kent's factory. He had been active in making wooden cabinets for the Thirties Series but he did not want to fabricate the more complex styles, especially those requiring the processing of veneers and multi-ply wood sections. While he did not actually make the console cabinets, his staff had to select and approve the designs of the cabinets that he purchased from his suppliers, the furniture manufacturers. To meet his customer's demands, Kent set up a cabinet-design group whose functions included working with marketing to select styles and costs, working with engineering to assure satisfactory form, fit and function in the new cabinets, and working with both in-house and outside designers to generate new, attractive designs that were then contracted to furniture manufacturers. The cabinet design and styling group maintained mock-up facilities and transferred sketches of candidate ideas into full-scale three-dimensional representations. The 1933 design program for Kent's styling, engineering and manufacturing groups divided along five lines, large and small consoles, standard and midget compacts, and automobile radios

This review continues with the big-chassis consoles, then looks at the standard compacts and their related small-chassis consoles, and compares the midget compacts. As the automobile radios came along in the design program for the compacts, they are described as variations.

MODEL 448

Model 448 was the big-chassis console that Atwater Kent introduced in 1933. It combined the good results of his earlier production experience and it performed well. It did not have some deluxe features, such as the silencing tube and the Tonebeam tuning indicator, but it did provide room-filling sound from its push-pull type-47 output tubes. Model 448 was accompanied by an F version for 25-Hertz service. As with earlier sets, the difference between versions was the power transformer's primary leakage inductance.

Model 448 was built on the big chassis that had been Kent's hallmark since the Model H. Its circuit closely resembled Model 469, one of the big-chassis sets of the previous group from late 1932. One difference was a technical improvement in coupling the local oscillator to the mixer input. Earlier sets had used inductive coupling, as did the Model 448, but in this set the coils for the RF input to the mixer and the oscillator

were wound on the same form. Both(coils were tuned by sections of the four-gang tuning condenser. The other two sections of the tuning condenser were used to tune two RF coils in the antenna-to-input circuit of the RF amplifier.

The RF amplifier, the mixer and the IF amplifier were type-58 tubes fed with AVC from one of the diodes in the type-55 second detector. The AVC for the amplifiers fed their grids but the AVC for the mixer went to the suppressor.

The cathodes of the IF and RF amplifiers were tied together and to the arm of a potentiometer wired as a variable resistor. The other end of the variable resistor went to biasing resistor. Changing the setting of the variable resistor changed the cathode voltage of the amplifiers and, because of the AVC voltage, changed the way the automatic volume acted in the circuit. This was called a silencing adjustment but it did not have the effectiveness of the silencing that was provided by earlier sets with functional silencing tubes. This control altered the effectiveness of the AVC, by reducing the amount of gain increase between stations while tuning, but it did not actually reduce the inter-station amplification and thereby silence the set.

The second diode of the type-55 tube developed an audio to the triode section. The amplified signal was fed through a transformer to the signal across the volume-control potentiometer from which it was fed to the output stage, a pair of type-47 tubes operated in push-pull. A tone switch connected four condensers across the secondary of the input transformer to let the listener select the degree of high-frequency reduction he wanted. Model 448 used the same dial mechanism that had been used on the big-chassis radios since the Seventies Series. In many ways it was a recognition feature of Atwater Kent consoles. The reason for the effectiveness of the tuning-control mechanism was that it spread the high end of the scale so that the pointer moved about the same number of degrees for ten kHz of tuning whether it was near 600 kHz, or near 1300 kHz. Behind the fan dial that the listener saw was an element called the pointer bracket. It was a slotted curve that was moved by condenser rotation and which, in turn, moved the indicator over the fan dial.

The factory made another change in 1933 that benefited the service people in working on the new line of radios. The circuit diagrams, published in the supplement to the *Service Manual* (March, 1933) included the voltages at the points of measurement instead of publishing a separate voltage chart. The diagram also noted the values of the fixed condensers and resistors and the resistances of the coils. The Parts and Price lists also tabulated the parts values. Apparently, the factory held on to the older system of parts identification because the colors of the resistors were noted along with the resistance values. From the serviceman's point of

view the new system was a major step forward in troubleshooting, because looking in the old *Electrical Values* pamphlet was inconvenient if not irritating.

MODELS 310 AND 510

Models 310 and 510 were the same radio, the difference in the numbers relating to the console cabinets. Both sets used the big-chassis. Model 310, Figure 73, was traditional in style with rounded front edges. The chassis in that set was identified as the Type 10. It did not show the model number of the radio set. That was found on the escutcheon on the front of the console between the fan dial and the Shadowgraph.

Model 510, Figure 74, was housed in a modern cabinet edged with inlaid aluminum strips. It had very sharp square-cornered edges along the sides and on the top. The nameplate on the big-chassis in Model 510

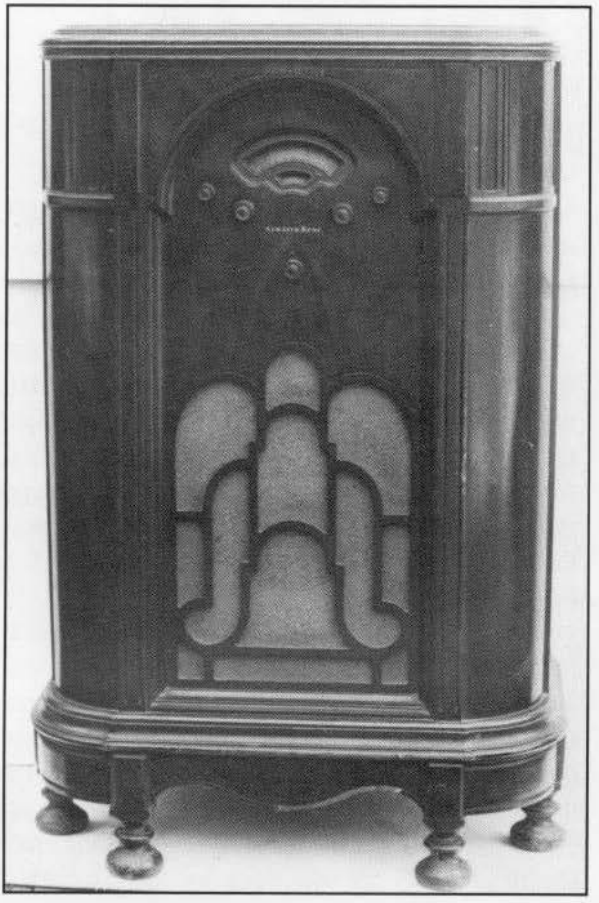


Figure 73. *Model 310. This radio was meant for the same customers who were attracted to the 12-tube sets. It used newer tubes and offered the same performance. The curved console offered Classic styling.*

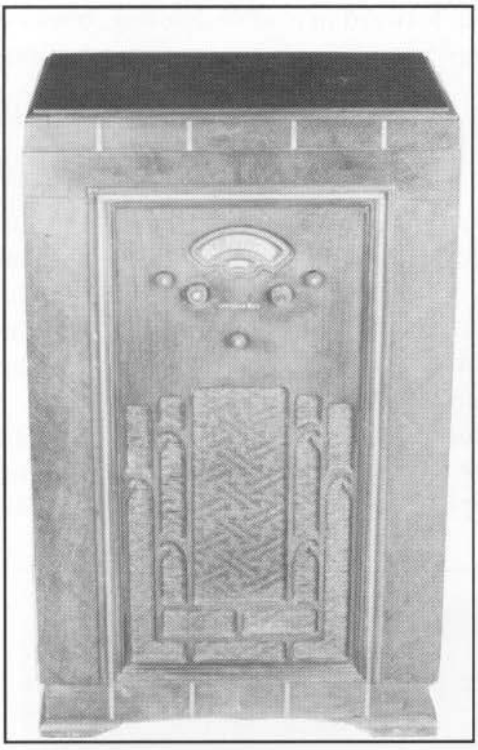


Figure 74. *Model 510. This was the same radio as a Model 310 except that it offered modernistic styling, with sharp corners and flat panels. Both of these radios marked their chassis Model 10.*

was blank where the model number would have been stamped. The Model number for the radio set, 510, was stamped on the escutcheon plate, in raised numbers at the same location as for Model 310.

The Type 10 chassis for Models 310 and 510 shared some of the characteristics of earlier sets. The radios had two reception bands, one was the broadcast band from 0.55 to 1.5 MHz and the other was a short-wave band from 1.5 to 3.5 MHz. The chassis used an IF of 130 kHz, which had been proven to work satisfactorily for the broadcast band, but which was questionable for short-wave reception because of the closeness in frequency of the image. Perhaps that was the reason the short-wave band on Type 10 was calibrated only to 3.5 MHz when the dial could be rotated to 5 MHz.

The Type 10 chassis had an RF amplifier, a mixer, and one IF amplifier, all type-58 remote-cutoff pentodes. Its local oscillator, AVC rectifier, audio detector, and first audio amplifier were type-56 triodes. The two output power tubes were type-2A5 pentodes. The Type 10 chassis sets had Shadowgraph tuning and silencing, but their circuitry was a little different from the earlier sets. Silencing action in the 10 chassis took place by setting a threshold for AVC action, with bias on the cathode of the IF stage. This was done by the listener, using the silencing control. The amount of bias was increased when the silencing action was desired,

as with weak signals between stations. Because there was no AVC voltage from the weak signals, the controlled tubes would have tended to increase their amplification between stations. The higher cathode voltage set by the silencing control tended to limit the increase so the set stayed quieter. This worked well for big-city stations but for small stations the sensitivity was reduced excessively.

The Shadowgraph was a means of setting the radio directly on frequency. It was actuated by the plate current of the RF and IF-amplifier tubes and the mixer. The Shadowgraph was used on later sets and is explained more fully in their reviews. Another change in the Type 10 from other sets that came out at about the same time, and earlier, was in the second detector where two triodes are used. One triode, wired as a diode, was used to rectify the IF for AVC. The second triode was also wired as a diode and rectified the IF to recover the audio signal. When the production of Model 310 was started, type-55 tubes were available and were used in Models 612 and 448. Perhaps the design of Model 310 was older and the decision was made to not update the set to eliminate the extra tubes.

The triode section of the type 55 would have been able to replace the audio amplifier to save a third tube but that would have reduced the set's overall amplification too much, especially since it only had one IF amplifier. Another thought: Maybe the number of tubes was a selling point!

MODELS 246 and 266

Model 246, Figure 75, introduced a number of improvements to the Atwater Kent product line for late 1932. It had the first cabinet with the elliptic top. The low profile appealed to customers of that day and Kent produced three radios with that appearance, Models 246, 217 and 708. The other two are reviewed in later segments. Model 266 was the console version of Model 246.

The loudspeaker was mounted on the chassis between the power transformer on the left and the tuning condenser on the right. By mounting the loudspeaker on the chassis instead of on the front of the cabinet the overall height of the radio was reduced to twelve inches. The grille for the loudspeaker was very simply styled in the tradition of "art-noveau." The dial window was placed to the right and a little above the center line of the grille opening, with the tuning knob directly below. On the left side was a blank escutcheon that balanced the dial window with the volume-control knob below. Under the loudspeaker opening was the tone-control switch. Model 266 was the console version of Model 246. The arrangement of the controls, dial window and escutcheon were the same as in the compact, Model 246. The speakers were different in two ways. The console speaker was a little larger in diameter and it was mounted in the console below the chassis.

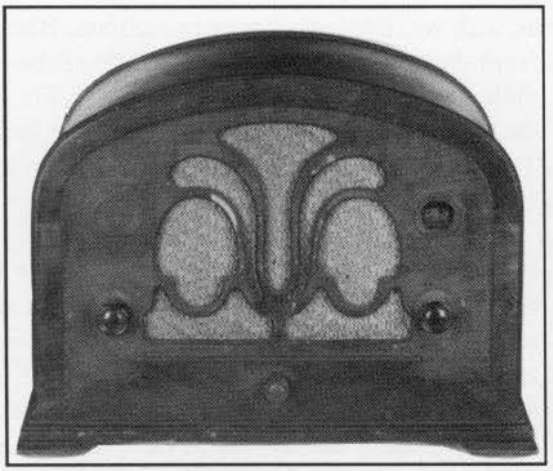


Figure 75. *Model 246. Variations of the cathedral motif were popular in the mid-1930s. One of these was the flattened curve of this set. The other feature was the tiny window for the dial.*

The circuit of Model 246, at first glance, seemed to be a throw back because it did not have an RF amplifier. Instead it was a broadcast-band radio with an IF of 262.5 kHz and two resonant circuits between the antenna and the mixer. Together these improvements got rid of the potential image problem. The other improvement that made the throw-back criticism invalid was the substitution of pentodes for the tetrodes formerly used in the mixer and the IF amplifier. Their increased gain brought Model 246 up to expectations for the bottom-of-the-line set in the early 1933 offering.

Model 246 incorporated a type-55 double-diode, triode for the second detector functions. One diode provided the AVC voltage that was fed back to the grid of the IF amplifier and the suppressor of the mixer. The other diode was used to develop the audio signal across the volume-control potentiometer. From there it was fed to the triode section of the type-55 tube, amplified and fed on to the output tube through a resistance coupling circuit. The output tube was a type-47 pentode.

In many ways Model 246 was a major advance in circuit engineering. It was the first Atwater Kent radio to incorporate the circuits that became standard in the industry. These included diode developed AVC, diode/volume control audio detection, resistance coupling, double-tuned IF transformers, pentode amplifiers and cathode injection of the signal from the local oscillator to the mixer.

MODELS 217, 427, 667

Model 217, Figure 76, was the seven-tube version of the low profile, rounded-top, compact radios. It was a two-band receiver, covering the frequency range from 540 kHz to 3.2 MHz. Like other receivers that had only one short-wave band, the radio tuned up to 3.5 Mhz but the dial was only calibrated to 3.2 MHz. The cabinet for Model 217 was very similar

to that of Model 246, with four knobs and the window dial. The pattern of the loudspeaker-grille decoration was that of a highly stylized wave, or perhaps the letter "W".

Model 217 was constructed on a chassis that was almost identical to Model 246. The difference was that, in the blank space to the immediate left of the tuning condenser on Model 246's chassis, another socket hole was punched out. This was used for the seventh tube, the RF amplifier in Model 217. The tube line-up was; RF amplifier, mixer and IF amplifier, all type 58; second detector type 55, local oscillator, type 56 and the pentode output tube, type 2A5.

Comparison of Model 217 and Model 627 offers a lot of understanding of the receiver-engineering progress that had been made by Atwater Kent's engineering staff. In the year between 1932 and 1933, the design of good radios for the economic-middle class had stabilized. Both of these sets had the same stage line-up and used the same tubes. These were types 58, 55 and 56. (The type 47 in the Model 627 was not significantly different from the type 2A5 in the Model 217.) There was little change in how these tubes were biased and operated. The big change had come the year before when the type-35 tetrodes were made obsolete. Circuit design was no longer the driving force in engineering.

Neither was there was not much engineering required for the small changes in the chassis mechanical design. In the earlier set the chassis was approximately 14 by eight inches with the tuning condenser and a fan dial in the middle. In the newer set, the chassis was the same size but it was laid out differently. The condenser with a simple window had been moved to the right and the loudspeaker was fastened to the chassis in the middle. These changes were not big engineering jobs. The stresses of chassis piercing and punching, shaping, plating, handling for assembly

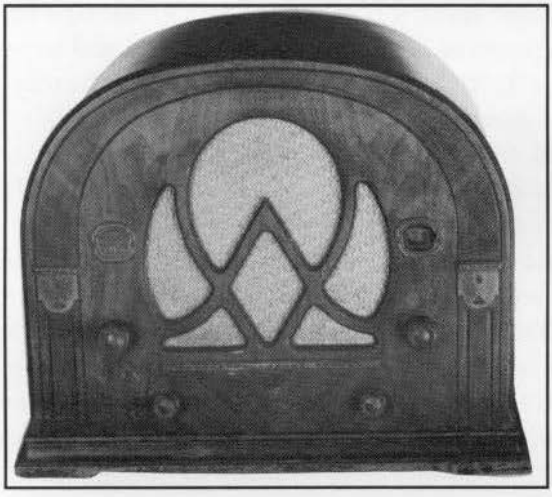


Figure 76. *Model 217. This was Kent's second set with the flat-curved case. It offered a slightly different grille, a short wave band, and another tube. All these sets had good speakers and consequently produced good sound.*

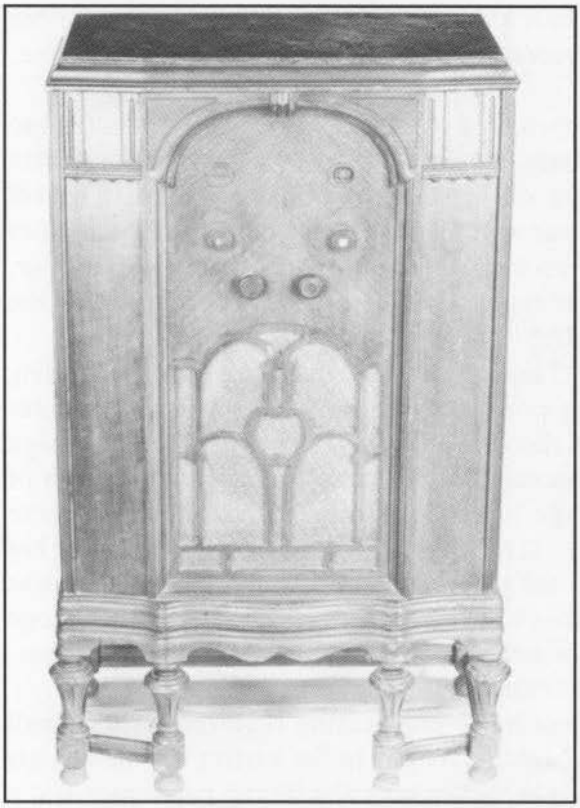


Figure 77. *Model 427. This console illustrates how the style changed in the first years of the 1930s. The legs got sorter and the sets tended to have a flow instead of being a decorated box.*

and withstanding shipping impacts did not have to be re-evaluated in depth. They needed only rechecks.

The engineering work was more directly related to factory tool design and modification than it was to electrical design of even mechanical chassis design. For every radio design that Kent wanted to put into production, there had to be some electrical and mechanical redesign for layout, some laboratory evaluation of performance and quality and some pre-production assembly to establish rates, parts flow in the factory, final test and inspection, and preparation for shipping.

In earlier years Kent had found out that very acceptable consoles could be produced using the compact chassis. When his customers could not afford the big-chassis consoles, his staff was ready with the compromise. The difference between those two styles was only cabinetry and the loudspeaker. The impact on engineering and on manufacturing was not great. The extra effort was in enclosure styling and sub-contractor evaluation for the different cabinets, and in sales and dealer distribution. The dealers benefited by having a broader line, but the factory distribution had to equip itself to efficiently handle the extended variation. Kent also found the solution to another problem, building radios with higher output power.

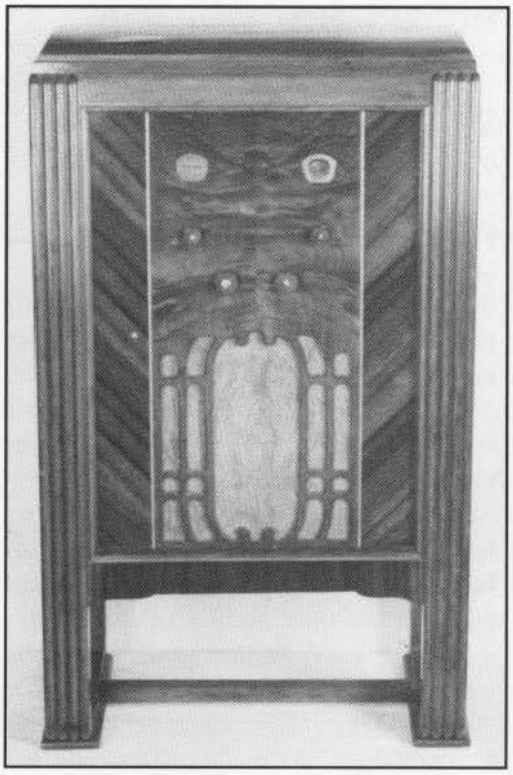


Figure 78. *Model 667. The modernistic style was relatively popular so Kent sold a seven-tube set that combined the features of the Models 427 and 510 and the chassis from Model 217.*

The answer was to confine the high-power capability to the consoles that used the big chassis.

Model 427, Figure 77, was a more-or-less traditional console. It was a little advanced in that it had very short legs and it looked a bit different because of the knobs and dial escutcheon. It was not remarkable in appearance. It was the kind of radio that a moderate-income family would have welcomed in the living room. Model 667, Figure 78, had the same chassis and speaker and offered the same arrangement of controls and dial escutcheon, but presented a much different appearance. It was a very early example of the flowing style, which was accentuated by the fluted columns that defined the front of the set. The tradition of the legs was not quite gone with this cabinet since the box was not carried to the floor. A family with more modern tastes would have found Model 667 a worthy companion. If the Model 217 and its console equivalents, Models 427 and 667, were the only radios that Kent was to build, he could have relaxed and reaped his reward, but that was not to be. The time was near when a smaller radio had to be offered to his market, and more important to engineering, a new generation of 6-volt vacuum tubes was soon to replace the 2.5-volt tubes. Before his engineers could start designing with the totally new set of tubes, however they had to meet two other market demands.

MODELS 217D, 427D, 667D

The three "D" versions, 217D, 427D, and 667D used two almost identical chassis. Like the ac versions the difference was in the attachment of the loudspeaker. For Model 217D, the speaker was attached to the chassis. For the others the speaker was a little larger and connected by a cable. Although the D chassis was similar in circuit functions to the ac chassis, it was limited in available B+ voltage by the use of the filtered dc line, to about 100 volts. By selecting tubes with 6-volt filaments for the RF and IF functions and type 43 pentodes with their 25-volt filaments, and connecting them in series with the loudspeaker field, the total drop nearly equaled the line voltage. A bridged pilot light and a small series resistor brought that circuit into balance. The tube manufacturers had produced 6-volt equivalent tubes for many in the 2½-volt series. The Atwater Kent engineers got some early experience with these new tubes but the designs did not differ significantly. Type-58 tubes had become the commonly applied RF and IF amplifiers and the type-78 pentode equivalents were almost substitutions. The same was true for the type-37 triode used as the local oscillator, and the type-75 double diode, triode used for the second detector.

The big difference between the ac and the dc versions was in the output stage. With only 100 volts a single pentode was unable to put enough power into the loudspeaker to make the set equivalent to the ac version. Kent's engineers therefore paralleled a second output tube. This, in effect, doubled the available output power, bringing it up to a value only a little less than the ac version. For general use, the sensitivity of the D version was adequate, especially since the AVC action was available for controlling the response to the big stations. Unless room-rocking output was required, the available power was acceptable. For more output, Kent was ready to sell the big-chassis consoles.

MODELS 427Q and 387

Customers who wanted a battery-powered radio of high quality and attractive appearance were numerous enough in 1933 to justify Atwater Kent's producing radios that met their expectations. As with the other sets in the 1933 Series, the battery radio was built on a common chassis with two cabinet styles. The compact was Model 387, Figure 79, with an arched cabinet with richer decoration than some of the earlier sets. The console was Model 427Q with the same appearance as the other Model 427s.

The chassis for these two radios was the same size as Model 427 but it was laid out differently. The three-section tuning condenser was mounted



Figure 79. *Model 387. The modified cathedral style of Model 228 was sold in a battery version that was derived from Model 82Q. It was the only battery set that did not use the Q designator.*

in the middle of the chassis with the IF transformers to its left. The dial was a small fan with the knobs arranged in a triangle underneath. The circuits were an RF and an IF amplifier using type-34 tubes, a detector using a type-32 tube, two stages of audio amplification using three type-30 tubes (the output in push-pull) and a new tube, the type-IA6, in the function of the mixer. The lA6 was a pentagrid converter that used its first two grids as the grid and anode of the local oscillator. The fourth grid was used to inject the signal from the RF-amplifier stage, and grids three and five acted as screens around the injection grid. Conversion took place because both the local oscillator and the RF signal modulated the electron stream of the tube. Models 427Q and 387 had two bands, one for broadcast and the second for the police signals from 1.5 to 3.5 kHz. An excellent feature of this radio was the double-tuned IF transformers used for the input and the output of the IF amplifier. Volume was controlled manually by varying the screen voltage on the amplifiers and the mixer. There was no AVC.

MODELS 708, 808 and 808A

As with the other medium-chassis models in the 1933 Series, Models 708 and 808 were a pair. Model 708 was a curved-top compact and Model 808 was the corresponding console. Model 808A added a Shadowgraph tuning meter to the circuits of Model 808.

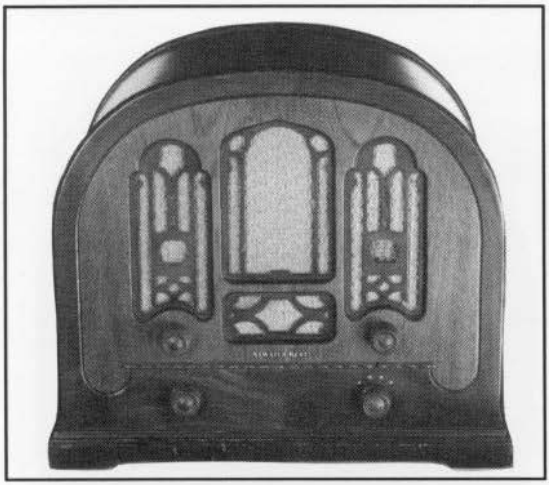


Figure 80. *Model 708. This radio is the third and last of Kent's flat-curved receivers. It was a good performer with eight tubes and offered a very attractive, classic appearance.*

Model 708 was a very attractive, compact receiver with good sensitivity, tone and volume. It offered four bands, 550 to 1500 kHz, 1.5 to 4 MHz, 4 to 10 MHz and 9 to 20 MHz, but did not have variable-speed tuning. However, it did have a planetary drive that isolated the tuning knob from direct connection with the condenser shaft. Separating stations at the top of the highest band was difficult. The cabinet was the largest of the elliptic-topped series. (The three were Models 708, 246 and 217.) Like Model 246, the cabinet appeared to be a little wider than it was tall. The grille work for the speaker opening was traditional in style and delicate in rendering. The resemblance of the fretting to the open-chain style on Model 165 and to the decoration on the Treasure Chest, Model 555, was strong.

Model 708 had an RF amplifier, two IF amplifiers, a mixer and a local oscillator, all type-58 tubes. The second detector was a type-2A6 double-diode, triode and the output tube was a type-2A5 pentode. The selectivity of the set resulted from three double-tuned IF transformers operation at 472.5 kHz. AVC was generated by one of the diodes in the second detector and used to control the RF and first-IF amplifiers by connecting to their signal grids through the tuning coils. AVC was also used on the mixer by altering its suppressor voltage and therefore the conversion gain. Local-oscillator signals for the different bands were injected by being inductively coupled from the oscillator resonant coils into the input coils of the mixer.

Tuning was done by rotating a four-gang, single stator per gang, condenser. The condenser, the RF amplifier, the mixer, the IF amplifiers and their coils were mounted on a super-chassis that was then mounted above the main chassis of the radio. The band-switch and the RF coils were mounted below the chassis. A set of wires were soldered to the elements in the

super-chassis and during assembly, then threaded through holes in the main chassis. The wires that ran between these two sets of connections were soldered as part of the final chassis assembly.

The tuning condenser resonated two coils between the antenna and the input of the RF amplifier, one coil between the RF amplifier and the mixer, and the other the frequency-determining coil of the local oscillator. A planetary drive between the knob and the condenser shaft was effective for the broadcast band. In 1933, when the set was new, DXing for small short-wave stations, or listening to amateurs had not become popular. Simple station selection was done by going back to the place on the dial that had been located by an earlier, careful search. Locating shortwave stations in 1933 was like locating broadcasting stations a decade earlier, when all the dials read from 0 to 100.

Model 808 was the console version of Model 708. The chassis was the same as in the compact, but the loudspeaker was a little larger and placed below the chassis in the main body of the console. The cabinet was plain with the window dial right above the tuning knob, and a blank escutcheon plate to the left over the volume-control knob. The layout of the knobs and the dials was the same on the console as on the compact.

Model 808A came out about a half year after Model 808. It was the same radio but a tuning indicator, a Shadowgraph, had been added. The indicator was a simple meter movement on which a vane was mounted, placed in the path of a light beam that shone on a small window visible in the front of the set. The meter was operated by the plate current from the RF and IF amplifiers. That current was increased or decreased by the AVC action of the set, so the shadow cast by the vane on the window changed with the current. The shadow got smaller as the signal strength increased, and indicated that the station was properly tuned.

MODEL 555

In 1933 the radio market had reached such a level of saturation with large radios that the active manufacturers realized that survival called for new designs. The demand was for smaller radio sets, much lower prices, moderate performance, only basic features, and ways to reduce the financial shock of purchase. This set of requirements was not greatly different from those that led to the popularity of the Model 84 and its related sets. It was also not different from the demands that led to even simpler radios when the technology made them practical.

Kent met the demand for reduced-price radios by putting the five tube superheterodynes on the market. The first of these was Model 555, Figure 81, sometimes called the Treasure Chest. It was enclosed in a

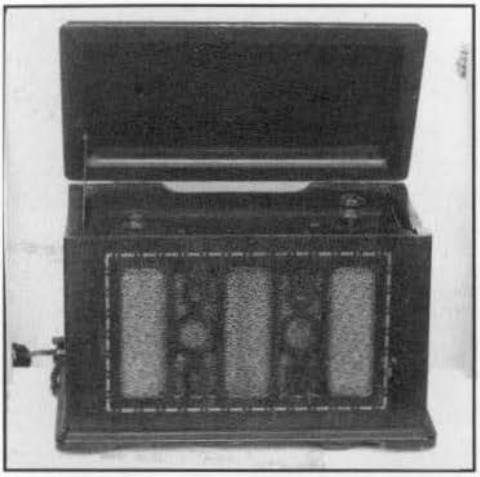


Figure 81. *Model 555. The same radio that was used in Model 165 (above) was sold in this novel treasure-chest design. This set was a bit more expensive so it did not appeal to as broad a group as the Model 165.*

classic-style chest, not unlike what might have been used to store the table flatware between visits from the relatives or special friends. The chassis of the radio was reduced in size from those in the contemporary compacts to mount the power transformer, the five tubes and a loudspeaker. The loudspeaker was fastened with brackets so that the cone was outboard and in front of the chassis. The method was similar to way in which the Model 708 and Model 217 were laid out.

The tuning shaft and the shaft of the volume control were vertical, with their instruments mounted with brackets to permit this orientation. The illuminated dial was viewed through a hole in the figured horizontal panel. The shafts were let through the panel and capped with their decorative knobs. The panel was revealed when the lid of the chest was raised.

At about this same time radio designers had recognized that the superheterodyne could be further developed to reduce its cost while maintaining its performance. The type-55, double-diode triode simplified the second-detection functions while providing AVC and controlled audio for feed to the well-established type-47 output pentode. The pentode IF amplifier had proven very satisfactory for sets of moderate sensitivity operating with moderately large signals on the broadcast band. The type-58 remote-cutoff pentode had come close to standardizing the design of IF amplifiers. The circuit that had necessitated the extra tube in earlier radios and therefore had made the reduction to five tubes impractical was the mixer/oscillator. Using separate tubes for the oscillator and the mixer was very satisfactory from a performance standpoint, but it was unacceptable from the cost-reduction drive for the five-tube radio.

Another application of the pentode small-signal amplifier provided the means of achieving both requirements. It was called the "Autodyne" and used the pentode to provide the oscillator and the means of converting

the input signal to the IF frequency. The concept of generating an oscillation and mixing it with another signal had been known since Harry Houck had developed the Second Harmonic Superheterodyne for RCA nearly a decade before. The use of a pentode with suitable selective filters and feedback instead of an earlier triode was a matter of experiment rather than basic-circuit development.

A closely-related activity was being pushed in the development of tubes. This was the addition of control elements (grids) to produce a tube especially suited to this service, the pentagrid converter. This means had not become available at the time that Kent made his bid for the small compact radio set market with Model 555.

Kent's engineers used the type-57 pentode tube as both the oscillator and mixer. At the plate of the mixer one filter, the double-tuned IF transformer, extracted the IF part of the stream. Another filter, the oscillator resonator, extracted the locally-generated wave and, through a coil in the cathode of the mixer, closed the oscillator loop. The incoming signal from the antenna was fed into the signal grid of the mixer to modulate the alternating part of the electron stream. To keep image responses under control, double tuning was done in the RF circuitry between the antenna and the mixer. With an IF of 262.5 kHz, the image response was improved over the earlier sets, such as Model 84 with its IF of 130 kHz. In big cities, however there were frequency combinations that could give image problems, so the double tuning was retained.

Although a double-tuned IF transformer was used between the output of the mixer and the input of the IF amplifier, Kent's engineers did not use that kind of filtering at the output of the amplifier. Instead, the plate of the amplifier was connected to a simple resonator and through blocking condensers to the diodes of the second detector. The five-tube circuit performed adequately for its time but its adjacent-channel rejection was not as good as big-city channel spacing would require.

Model 555 was a eye-catching radio and attracted substantial attention to Atwater Kent's new product line. While no production figures are available, the test of time has shown Model 555 to have been a good seller. It went through three Types and stayed on the market for a year. Model 555 radios in collections today show substantial wear around the tuning and volume knobs. This shows that the earlier users put in a lot of time with their radio.

MODEL 155

In 1933, many communities were still being served with dc house power. In some of the larger cities that had started with dc distribution,

the need to use electric energy that was produced a long distance away had mandated the changeover to ac. Thus ac power, not dc power, was necessary to accommodate further expansion. However, there remained many buildings that had not been connected to utility power but had installed their own generating capability. All of these potential customers had to reject ac radios so there was a small but viable market for dc-powered sets. The older dc-only radios were serviceable, but for a manufacturer looking toward the future these were products whose time had passed.

Tube manufacturers had developed the techniques of increasing the filament voltages and reducing the required current of several tube types. It was well known that a string of filaments could be very usefully connected across a source. Efforts to connect a string in series across a power line had led to two new types, a rectifier and a power-output amplifier. These were type 25Z5, the rectifier and type 43, the power pentode. Combining the series string with suitable accommodation for both ac and dc power input led to a new family of small radios.

Atwater Kent put three of these radios on the market. The first was Model 155, which came out in 1933. The other two were Model 275 in 1934 and Model 825 in 1935. The designs of all three of these radios were similar. They were directly derived from the five-tube, ac-powered superheterodynes that were a main part of Atwater Kent's product line.

Model 155 was to be a set in which costs were reduced as far as the required performance would permit. With the type-25Z5 rectifier, the power transformer was eliminated which lowered plate voltage and reduced the maximum output volume and overall sensitivity. By selecting a higher IF (262.5 kHz) and retaining the IF amplifier, the sensitivity would have been adequate. Kent's engineers selected the type-44 remote-cutoff pentode for the IF amplifier. The 6-volt double-diode, triode detector tube, type 75, was available for AVC and audio detection in the second detector. Kent's engineers had used its 2.5-volt version in Model 246, so reapplying the design to Model 155 did not present any problems. The AVC signal from one diode was used to control the IF gain. Audio output was developed across the volume-control potentiometer by the second diode. It was fed from the arm of the volume control to the triode section of the detector tube. The audio was then fed through a resistance coupling circuit to the type-43 output tube and to the electro-dynamic speaker.

The remaining cost item was the local oscillator, which had been a separate tube. The use of a single tube to provide both an oscillator signal

and a mixing electron stream had been known since Harry Houck had developed the Second Harmonic Superheterodyne for RCA nearly a decade before. See Model 555 for more information about the Autodyne.

Kent's engineers used the type-77 tube as both the oscillator and mixer. At the plate of the mixer one filter, the double-tuned if transformer extracted the IF part of the stream. Another filter, the oscillator resonator, extracted the locally generated wave and through a coil in the cathode of the mixer closed the oscillator loop. The incoming signal from the antenna was fed into the signal grid of the mixer to modulate the alternating part of the electron stream. To keep image responses under control, double tuning was done in the RF circuitry between the antenna and the mixer

The power-supply portion of the radio took some careful circuit design. Required were: rectification and filtering of the ac input, pass-through of the dc input, reverse plug protection, field excitation for the loudspeaker and bias for the output tube. These requirements were met by using the type-25Z5 in a doubler circuit on ac, and using only one half of it on dc. The field coil of the loudspeaker was used to filter ac, but was switched so that on dc a part of it was fed from the type-25Z5 tube in parallel with the circuitry part of the set. No filtering was needed from the field coil of the loudspeaker when the set was operated on the dc mains. Bias was obtained from a tap on the field coil winding.

MODELS 165, 185 and 525

Model 165, Figure 82, was introduced at about the same time as Model 555. It was offered in a rounded-arch cabinet for potential customers who preferred that style. With Kent's earlier compacts and the radios of several other manufacturers the arched top had become popular for small, compact radios. Kent added a feature to the five-tube set by making a second band available to the interested listener. In 1933 several city police systems used frequencies near 1.8 MHz for communicating with their cars.

Kent modified the RF coils by adding taps to them and connecting them through a switch. This made a short-wave band that ranged from just above the broadcast band to about 2.5 MHz. The circuits were not carefully tracked so the response was not uniform. The set was adjusted so that the police frequencies came in adequately but the rest of the upper band was less than useful. The input circuit of Model 165 was the same as Model 555 on the broadcast band, with double tuning to take care of image problems. The minor change to an IF of 264 kHz did not change the image response.



Figure 82. *Model 165. The market of the 1930s demanded a small, less-expensive radio. Kent produced this classic design. It played well and became very popular.*

A tone circuit was installed in Model 165. It was a condenser that could be switched across the volume control to reduce the high-frequency response of the audio circuits. The tone control was operated by the same knob which operated the band switch; turning in one direction switched bands and turning in the other reduced the highs.

By the time the Model 165 was ready for final design, the type-2A6 double-diode triode had been released. Kent's engineers used that tube to replace the type-55 that had been used in the Model 555 in all later five tube compact and console radios that operated with 2.5-volt filament systems.

Models 185 and 525 were identical to Model 165 in so far as electrical design was concerned. Model 185 was contained in a flattopped cabinet with diagonally-grained veneer and two silvery vertical stripes. The finish of the cabinet was a little lighter to enhance the wood grain. Model 525 was a console, plain in style and finish. It was produced for sale to families that were not interested in high-priced, full-featured, deluxe radios.

MODELS 165Q and 525Q

Models 165Q, Figure 83, the small compact and 525Q, the console were the battery versions of Models 165 and 525. Their cabinets were nearly identical in size and style. Only by looking at the chassis labels or the tube lineup could the battery versions be recognized from the ac versions. The similarities carried into the mechanical design and the circuits as well. Of course, one look at the loudspeaker would provide identification for which was the battery set, but if the chassis was out of the cabinet, recognition became more difficult.

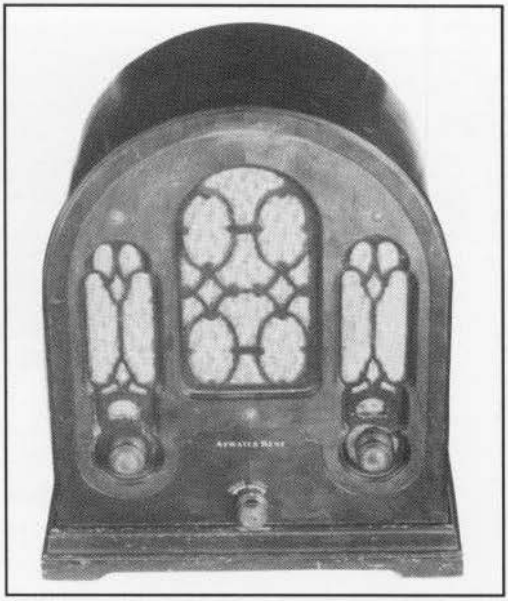


Figure 83. *Model 165Q. The Model 165 (above) had been a good seller. To keep that market, Kent put out this similar set. The differences between the sets were minor.*

The battery versions used a type-1A6 pentagrid converter for the local oscillator/mixer function. The circuit was similar to Model 427Q, differing only in the RF-input circuitry. Model 165Q did not have an RF stage but used a double-tuned antenna circuit to obtain good frequency discrimination. The IF amplifier was a type-34 tube with a double-tuned input transformer and a simple resonant output transformer. The detector was a type-32 tube operating as a grid-leak detector, its output resistance coupled to the first AF amplifier, a type-30 triode. The audio signal was then coupled through a transformer to the output tube, a type-19 tube which was operated in Class B to provide a maximum of nearly two watts of output.

The loudspeaker was the limiting item in the audio chain. It was a moving armature magnetic speaker, a little better than the old type-E, but not nearly capable of reproducing the full output of the Model 165Q radio. Nevertheless, this Model went a long way toward preserving Kent's reputation for quality radio sets.

MODELS 636, 756, 756B

In 1931 Atwater Kent produced his first automobile radio. It was a battery-operated TRF set (Model 81) with good sensitivity and adequate power output. The next year he upgraded the radio by making it superheterodyne (Model 91) but it was still powered by dry batteries. One tends to question why Kent did not go to a motor generator for power with the first set since rotating automotive-electrical equipment was an earlier, successful part of his business. Perhaps his technical

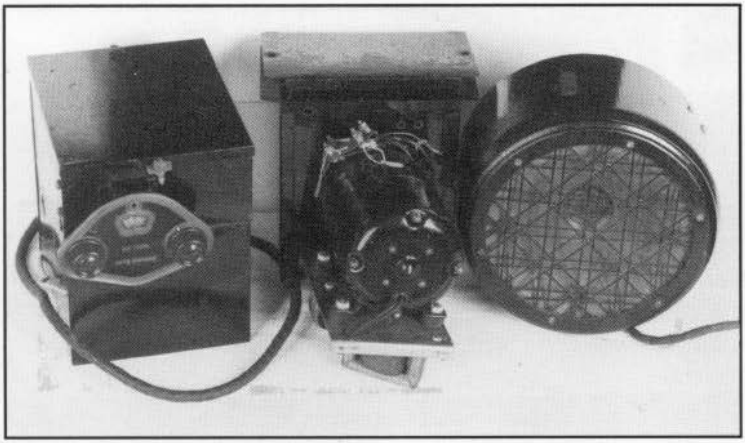


Figure 84. *Model 636. Kent's first automobile radio was a battery set dressed in a metal box. This radio used a motor-generator for B power, had an over-designed filter unit, and a separate loudspeaker.*

staff lost their machine designers after the automotive-electrical business was shut down in the late 1920s.

For 1933, the factory produced Model 636, Figure 84, and Model 756, two versions of an automobile radio that was an improved Model 91. These radios were equipped with a motor-generator system to provide plate power. Model 756 was Model 636 with a remote (steering-column head for control). Model 756B was Model 756 with extra cable lengths for under-board or trunk mounting of the radio containers. The basic radio was Model 636. Its RF and IF amplifiers were type-39 pentodes with AVC taken from one of the second-detector diodes. The mixer was a type-36 tetrode that was operated as an Autodyne converter. The second detector was a type-85 double-diode, triode. The audio part of the signal was recovered by the second diode and fed through the volume control to the grid of the triode section. The output of that section fed a center-tapped secondary transformer, which was connected to the two output tubes. These were type-41 pentodes operated in Class A.

The machine that converted the battery voltage to a little more than 180 volts was called a Dynamotor. It had a single armature with two major windings and two commutators. There was a two-pole field structure with compound windings to provide a nearly-constant output voltage. The dynamotor input was filtered with condensers and a choke, as was the output. The filters were contained on a separate panel in the dynamotor box. The speaker was also contained in its own box. The complete Model 636 radio occupied three boxes. Model 756 was made up of four containers because the control head was separate from all the others.

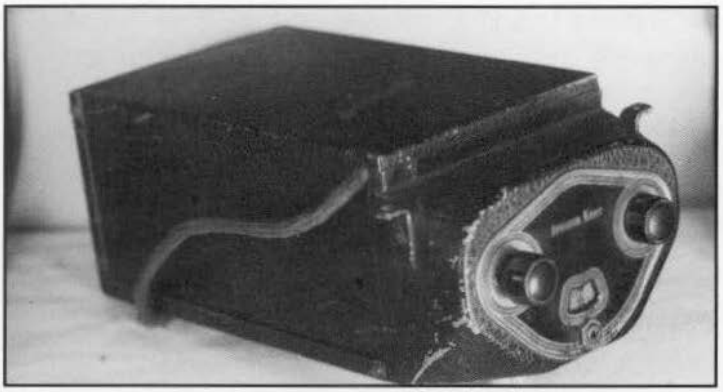


Figure 85. *Model 424. With the auto after-market demanding a low-priced set, Kent sold this under-dash model. Its synchronous vibrator eliminated the rectifier tube; the speaker was built into the bottom panel.*

MODELS 424 AND 534

The automobile radios that Kent produced up to middle-1933 were expensive sets that were excellent performers but well beyond the affordable expectations of the owners of the low-end cars of the time. Because this was a sizable and growing market, Atwater Kent produced a substantially different radio for sale to these potential customers. This set was Model 424, Figure 85, with tuning controls directly attached to the front of the set, and Model 534, equipped with a control head for attachment to the steering column.

To meet a low-cost budget for this set, the plate power had to be produced by a vibrator power supply and the tubes reduced to the minimum that would produce an acceptable, if not deluxe, output. The designs for the radio part of the set were available in the five-tube ac radios like Model 155. Design of vibrator power supplies had become fairly stable in 1933 so adaptation was the engineering job.

The difficult design was mechanical. The arrangement and attachment of parts and circuits was vital to the reliable performance of the set after its initial use. To produce a single box, the speaker had to be included with the tubes, tuning condenser, power supply and the little parts. This was difficult because of the vibration, the unavoidable environment of the automobile. Beyond the vibration and shock, there was high and low temperature, humidity and dust. Meeting all the requirements in a reliable single-unit, low-cost radio was challenging.

The tube line-up was a type-77 Autodyne converter, a type-44 IF amplifier with AVC, a type-75 double diode, triode second detector and a type-41 output pentode. The set probably performed adequately with

the larger stations in a city, but it must have been marginal for small towns a long way from big transmitters, unless the car was stopped and the engine and wind noise reduced to near silence. This radio may have done less for Kent's reputation than he would have wished.

Chapter 18

THE 1934 SERIES

Radio manufacturing in 1934 had become a stable business. The depression had taken its toll of battery-set builders of the mid-to-late twenties. The radios that now had broad appeal to the general audience required factory facilities and assembly skills that were well beyond the individual craftsman. The chassis was customarily punched out of sheet steel by a press that could be as big as 30 tons. Assembly of coils, condensers and transformers had become specialized manufacturing operations that were sometimes a part of the radio factory, and were sometimes the facilities of independent manufacturers. Atwater Kent made his own condensers and transformers, but companies like Cornell-Dublier and Thordarson made virtually the same components. The choice of which way to go was an economic one whose purpose was to reduce the cost and stay competitive.

The functions and styles of radios had also stabilized. The superheterodyne circuit with its specialized tubes was the only way that radios for the middle class were built. About the only technical variables left for customer choice were spectrum coverage, sensitivity and power output. The basic styles had been verified by customer sales and were divided into compacts or table models, and consoles or floor models.

Some manufacturers maintained their own cabinet-design groups, but the era of consultant artists had opened. Cabinet styles tended to reflect the important trends in the society and were influenced by other products like automobiles and architecture. The consultants, who were often active in styling other products, were in a very good position to provide suggested and better designs than the internal stylist in the several radio-manufacturing companies. Kent used a combination of both consultants and internal artists. One strong influence was the airplane dial. This resulted in fairly dramatic round dials for the radios, and where short wave bands were offered, colored lights added much to the modern appearance of the radio.

MODEL 788

Model 788 was one of three big-chassis, console radios that Atwater Kent produced in early 1934. At that time he had reached the practice of upgrading his line each year by adding new features to the prior

year's designs. Each year saw a whole series of radios, ranging from the least dramatic compact to the most complete console. In late 1933, Models 788, and 112 ranged from a sensitive, moderately-powered set (Model 788) in a plain console cabinet, through Model 711, a more powerful set, in a more fashionable console cabinet to Model 112, the most powerful in the most elaborate console. Later in the year he brought out another big-chassis radio, Model 511, and following soon after, the Model 509.

With Model 788, Kent's engineers introduced a new manufacturing improvement, a super-chassis for the high-frequency circuits of the set that was bolted to the top of the main chassis. It embodied an idea of Mr. Kent's that he had kept in the forefront of his manufacturing awareness since before the radio days. It was the concept of putting all the parts in a sub-assembly. The detector-audio amplifiers of the open sets were examples. Then there was Model 5 with all the parts except the tuner in one can. Following the concept of integration, Model 711 was built around a super-chassis that included all the type-58 tubes that the set used. These were the RF amplifier, the mixer, the local oscillator and both of the IF amplifiers. The 7½ by eight inch super-chassis was wired separately and fastened on top of the big chassis. It carried the four gang tuning condenser.

The RF and oscillator coils were left under the big chassis alongside the band switch. The IF transformers were mounted on the super-chassis and individual switching leads were threaded from the sockets of the super-chassis tubes or from the condensers through holes in each chassis to the switch sections as appropriate. Atwater Kent did not build a cable to interconnect the two chassis. Replacing a resistor or a condenser under the super-chassis (but above the main chassis) was a difficult and painstaking task. From the service man's standpoint, that difficulty more than negated the superior design of the super-chassis.

The high-frequency circuitry of Model 788 was identical to that of Model 711 and Model 112. The RF part between the antenna and the RF amplifier was a simple tuned circuit on the short-wave bands, and a pair of resonant circuits tuned by two gangs of the four-gang condenser on the broadcast band. The local oscillator used tickler-coupled resonators, coupled tightly to the inter stage resonators between the RF amplifier and the mixer. Injection was by way of the inductive coupling of the coils. Each set was separately shielded. The IF of 472.5 kHz was amplified in two stages using double-tuned transformers.

For the second detector the Model 788 used a type-2A6 double-diode, triode. One diode produced an AVC signal which was fed to the first IF amplifier and to the RF amplifier where it was used on all bands. The plate current from these two stages was used to operate the tuning meter,

a "Shadowgraph." The Shadowgraph was a meter-like device that rotated a vane in the path of the light from a pilot bulb to a small screen visible in the escutcheon of the radio. Increasing an input signal from the antenna meant more AVC bias and less plate current in the IF amplifier. With reduced current, the vane acted to align itself with the light beam. Therefore, the shadow grew smallest with largest signal. The second diode developed the audio signal across the volume control. The tone circuit was a switch that connected condensers across this control. From the arm the audio signal was fed to the grid of the triode section of the second detector. From the plate it was resistively coupled to the output tube, a type-2A5 self-biased pentode. The maximum output was about three watts.

Model 788 was sold in several different cabinet styles. Kent made his chassis with a standard footprint and a standard escutcheon. The consoles were designed to accommodate those dimensions on the shelf for the chassis and in the panel opening for the controls. The speaker was hung from two hooks that engaged slotted ears on the sides of the speaker frame. Removing or installing a speaker in a selected console was a task that took much less than a minute.

MODEL 559

Model 559, Figure 86, was a four-band broadcast and short-wave set that provided medium output power and high input sensitivity. It was equipped with the same super-chassis assembly that was used in Model 788 and others. The RF amplifier, the mixer, the local oscillator, the two IF amplifiers, and the tuning condenser, were put together on a chassis that was later mounted above the main chassis of the radio. As long as the design of the circuits was stable, this was an economical technique for the factory. A later change, such as going to a pentagrid converter, made the super-assembly less practical because its mechanical design would have had to be revised and the factory tools altered. This happened in the year following the introduction of this series of consoles.

As with Model 788, Model 559 used type-58 pentodes for all the stages up to the second detector, and the oscillator coils were enclosed in the same shielded cans as the input coils to the mixer, so injection was to the grid by way of inductive coupling. For effective short-wave discrimination on the upper end of highest short-wave band, the bandswitch wafers were arranged to cut out one segment of each tuning condenser gang. This raised the quality (Q) of the coils and enlarged the space on the dial for easier tuning and better discrimination.

The second detector in Model 559 was a type-55 double-diode, triode. Its design was like that in Model 788, including the AVC function and

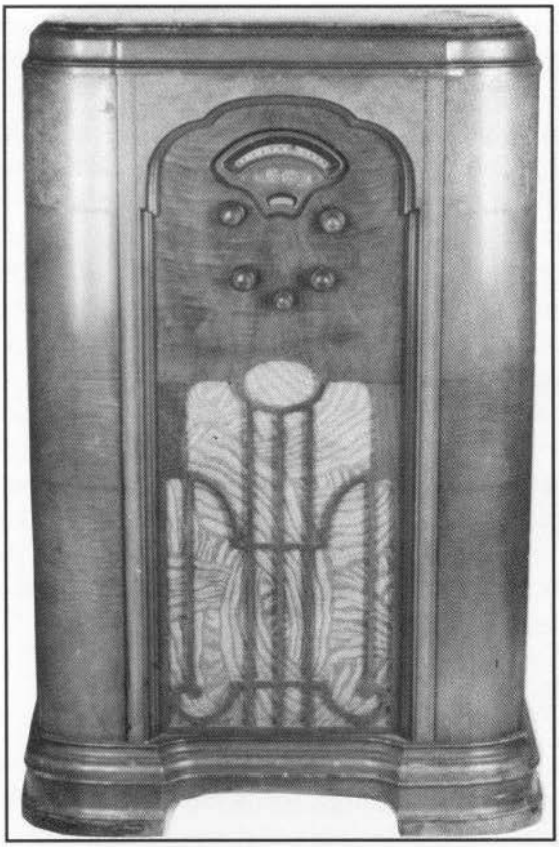


Figure 86. *Model 559. The middle thirties market included a strong interest in short waves. Model 559 excelled in this reception while offering good quality broadcast performance.*

the Shadowgraph. The second diode in the type-55 tube was used to derive audio from the IF signal. The audio was developed across the volume-control potentiometer and fed to the grid of the triode section. The amplified audio was fed by an audio transformer to the output tubes, a pair of 2A5 pentodes operated in Class A and delivering about six watts of audio power.

Tone was controlled by a switch which permitted the listener to broaden the bandwidth of the IF by modifying the inter stage transformer, and to shunt the audio high frequencies by selecting condensers connected between the plate circuit of the audio-amplifier stage (in the type-55 tube) and ground. Model 559 did not have an identified silencing control. Instead it had a sensitivity switch which permitted a change in the cathode bias of the second IF amplifier. This was the low-cost way of reducing the inter-station noise on the broadcast band when the radio was tuned from one favorite station to another, as long as both stations were strong.

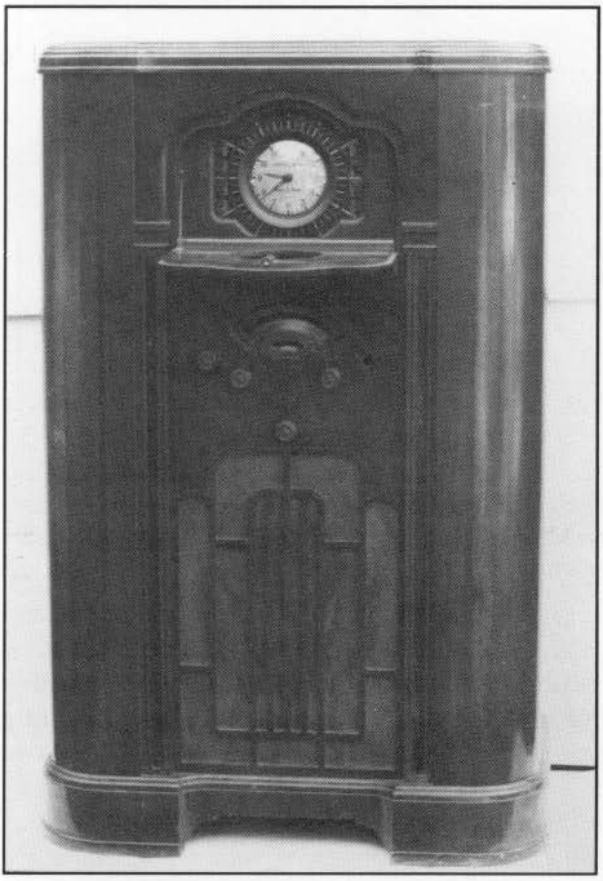


Figure 87. *Model 511. For the remaining domestic market of 1935, Kent produced this automatically-tuned deluxe receiver. Station selection was made via plug-in cords around the face of the clock.*

MODELS 511 AND 509

With Model 511, Figure 87, Atwater Kent offered to the fanciers of deluxe radios a set that was his best and most complete in 1935. It was called the "Tune-O-Matic." It had all the features that could be incorporated in a radio at that time. These were, automatic clock operation, clockcontrolled station selection, remote-station selection from the armchair, eleven tubes–all working–Class AB output from 2A3s at 15 watts with compensated tone, short wave, two IF stages with controlled band pass, and a modern console with a fan dial and visual tuning meter.

Model 511's main feature was an electric clock in a shallow compartment in the front of the set above the control and dial-escutcheon plate. The clock had its own escutcheon that included a ring of tip jacks arranged to correspond to the quarter-hours on the clock. On both sides of the clock were rows of cords, each terminated with a phone tip that was to be inserted in one of the jacks. When a cord was withdrawn from its panel, it was kept tense by its own spiral spring behind the panel inside

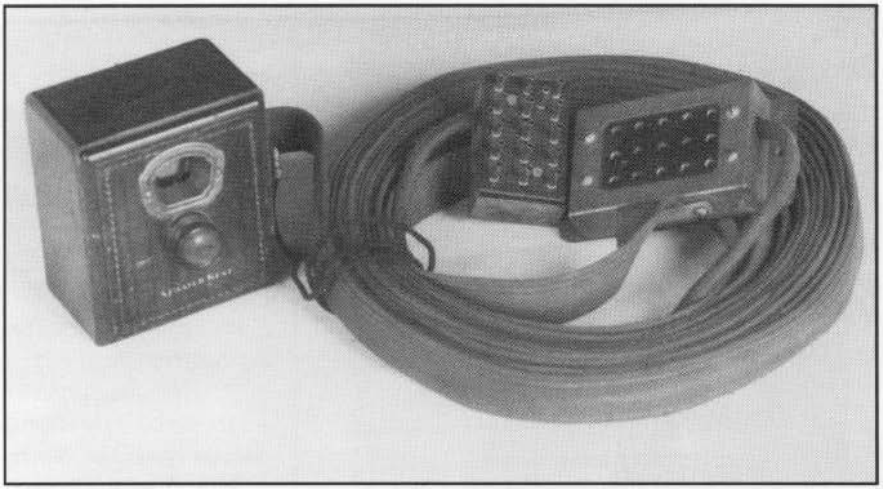


Figure 88. *Model 511, Remote. A listener could remotely tune the Model 511 using the pictured switch. The remote disconnected the clock switch and put control in the listener's hand.*

the radio. When it was released it was retracted by the spring and stored inside the clock panel. If the tip was inserted in a jack, the cord was retracted enough to curve around the clock behind a decorative ring. It could be left in that location for the typical, daily programming that brought Lowell Thomas into the home at 6:45 and Amos 'n Andy at 7:00 PM.

On each side of the clock the column of cords was divided into four segments, each having two cords. Each segment was related to a pre tuned station. When a listener had selected his program for a day, he withdrew the cords that were his station choices and plugged them into the jacks around the periphery of the clock. He located the jacks aligned with the markings on the face of the clock for the times he wanted the program to begin and end. As the hour hand passed the selected time, an electrical circuit was completed through the chosen cord and the radio was turned on. As part of the selection, the tuning condenser shaft was driven by an electric motor to the selected station.

The rotation stopped when a contact finger connected to the particular cord, and rubbing on the metallic portion of its adjustment disk, reached the insulated spot on the disk and opened the motor circuit. The disks were adjusted by turning them on the main shaft to the angular position of the station they were to select. The selection process explained above was initiated by the clock.

Selecting stations with Model 511 could also be accomplished by using a remote switch housed in a small wooden box, Figure 88, at the end of a flat cable that was connected to the clock assembly. A listener sitting in an easy chair on the other side of the room could rotate his

switch knob to one of seven station positions, or turn the radio off, or turn the operation over to the clock. The remote switch and the clock switch did not have a means of changing the volume that the radio was adjusted to produce. The listener had to make that adjustment at the front panel of the radio.

Model 511 was an interesting mix of circuits that Kent's engineers had used earlier in the product line, and of circuits that were new in this radio. The tube line-up makes this point. The RF and two IF amplifiers were type-58 tubes and the second and third audio amplifiers were type-56 tubes. The mixer was a type 2A7, new in this set. The second detector was a 2B7 and the output tubes (fourth audio stage) were 2A3s, used earlier only in Model 112. Even more striking was the IF frequency, 472.5 kHz, and the inclusion of only one short-wave band. It is noted that 472.5 kHz was the highest IF that Kent's engineers had designed into production radios. For the higher short-wave bands it was a necessary requirement. It would be interesting to find out why Kent included only one band on Model 511 when he had everything in place for including the other two. One reason might be that very nearly all the short-wave stations were assigned frequencies between 5.7 and 15 MHz. For Model 511, whose appeal was to the listener who wanted all the features, extra short-wave bands where no stations were transmitting would have been of little interest.

Model 511 used a double-tuned transformer in the input of the type-58 RF amplifier. Its output was a simple resonant circuit. These tuned circuit arrangements were used for both bands. The amount of inductance was reduced to tune the higher band. The mixer was a type-2A7 pentagrid converter. The first grid of the converter tube was used for the resonant circuit of the local oscillator. The second grid (effectively the first screen grid) was used as the plate and connected to the feedback winding of the oscillator transformer.

Between the plate of the converter and the grid of the type-58 first IF amplifier, there were two, double-tuned transformers. The second IF amplifier was also a type 58 but it was coupled with only one doubletuned transformer. AVC was fed to the grids of the RF and IF amplifiers and to the signal grid of the converter. The AVC signal was derived from one of the diodes of the 2B7-double-diode, pentode second detector. Plate current from the converter and first IF amplifier were fed through the Shadowgraph, a visual tuning indicator that Kent had used for two model years.

In Model 511, the audio signal was developed by the second diode in the second detector. Its load was the volume control, a potentiometer connected to the pentode section of the tube. The amplified signal was

fed to a single type-56 tube, whose output fed a push-pull pair of type-56 tubes through a transformer. The output of the pair was fed through another transformer to a pair of type-2A3 output triodes operated in Class AB. The chain of amplifiers was nearly identical to those used on Model 112.

Model 509 was very similar to Model 511. The RF and IF sections were the same but the audio part was different. In Model 509 the output tubes were two type-2A5 pentodes, operated in Class A with self bias, with an output of about six watts. The output stage was fed from the triode section of a type-55 tube, but the audio-detector diode was not in that tube. It was a type-56 triode with plate and grid connected together to act as a diode. The audio load for the type-56 tube, acting as a diode, was the volume-control potentiometer that fed the grid of the triode audio amplifier in the type-55 tube.

The tone-control circuit of Model 509 was different from that in Model 511. It had two parts, one a simple switch that shunted the plate of the audio triode with tone condensers, and the other a switch position that shorted a winding on the audio-inter stage transformer. This substantially reduced the amplification of low audio frequencies. Model 509 was offered with the same console cabinet as Model 511. In appearance, Model 509 was not visibly different from Model 511 and in deluxe features, aside from audio output, not functionally different.

MODEL 711

Model 711 was a set for customers who wanted a very complete radio but not the top-of-the-line. This Model didn't have the high output of Model 112, although it was much more than adequate. It wasn't low powered like Model 788 even though, from the standpoint of reception, both were very sensitive. All three of these sets (788, 711, 112) provided the broadcast and three short-wave bands. They tuned to 23 MHz and used the 472.5 kHz IF for the first time in the Atwater Kent line.

Model 711 used the super-chassis for part of the RF circuitry. The super-chassis was Kent's way of reducing manufacturing costs by building complex units as lesser assemblies for later installation in a final radio set. The interconnecting wires between the super-chassis and the main chassis were sized, skinned, tinned and soldered to the super-chassis during its assembly. When the super-chassis was fastened to the main chassis, the wire connections were completed and the wire ends soldered as appropriate. These wires make removal of the super-chassis impossible without solder-surgery. Putting a plug/jack combination and a harness in the inter-connection path would have made servicing (or restoration)

easier but it would have nullified the economy of using the super-chassis concept. That concession to servicing the radio, from the standpoint of the original designers, must have been an unnecessary and expensive luxury.

Model 711, along with the other two, used a type-55 double diode, triode as the second detector. One of the diodes was used to generate AVC. This control signal was used on the RF amplifier and the first IF amplifier. The plate currents from these two tubes were used to operate the Shadowgraph. The cathode of the second IF amplifier was switched by deck G of the band switch to a potentiometer acting as a variable resistor for controlled silencing. As the bias was increased by setting the potentiometer the size of the signal had to increase to come through the amplifier. Small signals between the selected stations during tuning were held quiet as the dial passed over them.

The second diode was used to develop the audio signal across the volume control. That signal was fed from the arm to the grid of the triode section of the second detector. The output of that triode was fed through a transformer to a pair of type-56 tubes acting in push-pull to produce an input signal for the last audio amplifier, a pair of transformer coupled, push-pull type-56-triodes. These two tubes drove the output stage through another transformer.

The output was generated by two type-2A3 triodes operating in push-pull Class AB. Their bias was the drop across the field coil of the speaker connected in the negative return of the power supply. The maximum output was probably about 10 watts. The tone control was a set of three switched condensers across the second audio amplifier grids.

MODEL 112

Model 112, Figure 89, was referred to in Atwater Kent's service literature as an All-Wave High-Fidelity Receiver. It was built to live up to its name. The important feature of this set was its short-wave capability. Along with that feature was the second one, the high powered output with its selectable bandwidth and tone compensation.

Model 112 provided four bands for reception: 540 to 1600 kHz, 1.4 to 4.0 MHz, 4 to 10 MHz, and 10 to 18 MHz. The set was equipped with a tuning condenser that had two stators in each of its four sections. The band switch changed coils for each band and also disconnected the second (larger) stator of each section of the tuning condenser when the highest band was selected. That permitted the quality of the high-frequency resonators to be maintained with consequent improvement in selectivity and image rejection.

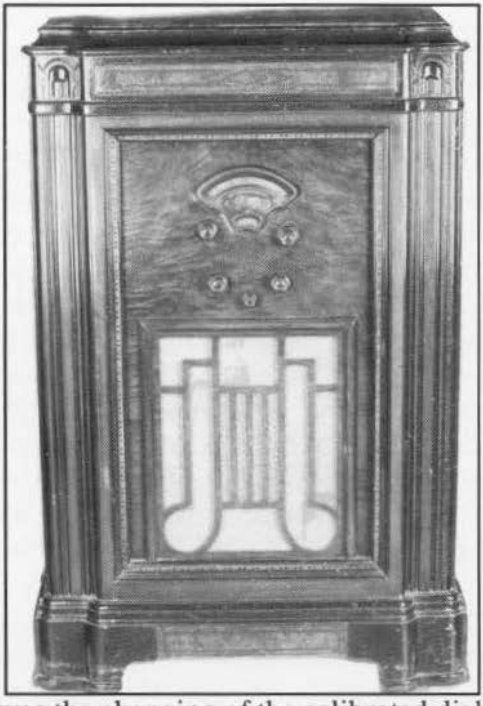


Figure 89. *Model 112. Some collectors rate this set higher than Model 812. It didn't have as much output power, but it tuned all the short-wave bands that contained broadcasting in the middle 1930s.*

A special feature of this radio was the changing of the calibrated dial for each band as the band switch was operated. Four calibrated scales were arranged on a track that let them move up and down as the band switch was rotated. The calibrations appeared in an arc-shaped slot, illuminated from the rear so that the listener saw only the dial for the range he had chosen.

Another feature built into the tuning system was a two-speed station selector knob. When the knob was pushed down and rotated, the pointer moved slowly across the dial. When the knob was lifted, an additional idler pulley was engaged and the pointer moved slowly to permit careful tuning of stations close together on the high short wave band. Also built into the escutcheon was the Shadowgraph tuning indictor. This was a meter operated by plate current from the RF amplifier and the first IF amplifier tubes. A vane rotated to produce a variable- width shadow in the beam of the pilot light that was visible in a window under the main fan of the dial.

The radio had an RF amplifier and two IF amplifiers, all built on the super-chassis used in the other sets in this series. It used type-58 tubes for these functions and for the mixer and the local oscillator. There were three resonant circuits on each band with the larger sections of the tuning condenser switched out on the highest band. The effect was to increase the quality of resonance on the highest band to maintain selectivity and image suppression.

The IF frequency was 472.5 kHz with two double-tuned transformers between the mixer and the first IF amplifier, one double-tuned transformer between IF stages and one double-tuned IF transformer between the second IF amplifier and the second detector. The IF signal was rectified for AVC by one of the diodes in the type-2B7 second detector tube and fed to the grids of the first IF and RF amplifiers. Audio was generated by the other diode using the volume control potentiometer as a load and fed to the pentode section of the second detector.

The output of the first audio amplifier (the pentode in the type-2B7 tube) was fed through a compensating network for tone control to the second audio amplifier a type-56 tube. That drove a pair of type-56 tubes in the third Audio amplifier which, in turn, drove the 2A3 output tubes. For more information about those stages see Model 511.

MODELS 137 and 257

Model 137 was essentially the same radio as Model 627. There were differences, chief among them that the set was made for the European market. It was built with a power transformer that had two primaries wired in series for 220-volt mains. Model 137 was fitted with a shortwave band to accommodate the foreign spectrum assignments in addition to the broadcast band that was used on Model 627. Foreign receivers were generally fitted with terminals and a switch to select the gramophone. Model 137 included this feature but it did not include the sensitivity switch that was used on Model 627.

The tube line-up was identical in the two sets. The RF and IF tubes were type 58. Another type 58 was used as the mixer with the AVC being connected to its suppressio to alter the converter gain. Both sets used type-56 tubes for the local oscillator and inductive injection between the oscillator resonators and the input resonators of the mixer. The second detectors were type-55 double-diode, triode tubes along with type-47 output tubes and type-80 rectifiers.

Both the Model 627 and the Model 137 used the small fan dial mechanism for station selection. On Model 137 the calibration scales were placed one above the other on the fan. The other parameter that separated the two sets was the IF. Model 627 used 130 kHz and Model 137 used the value that Kent's Europeans sets had chosen, 125 kHz. The IF transformers could be tuned to either frequency so the sets were identically constructed but tuned differently in final adjustment.

Model 257 was the console version of Model 137. It included one more change, substitution of the type-2A5 tube for the type-47 output tube. Type 2A5 incorporated several improvements in internal construction and was capable of slightly more power output.

MODELS 447, 487, 577

Model 447 had much in common with its predecessor Model 206. It used the experience that Kent's engineers had gotten on that radio but it included some very significant improvements. One of these was ha addition of another IF amplifier. The reason for a second IF amplifier in a short wave set was that for some listening, an increase in overall amplification helped to receive the station. This happened when the signal level was low and the noise level was high. Improvement in picking out weak short-wave stations was still greater if the bandwidth of the IF amplifier was reduced from music values (near 5 kHz) to minimal voice requirements, about 2 kHz. Model 447 incorporated a sensitivity control in the cathode of the first IF amplifier. This enabled a change in amplification but it did not alter the bandwidth. That feature had to wait for later Atwater Kent radios.

The tubes in Model 447 included the latest mixer/oscillator, type 2A7 and the new double-diode, triode, type 2A6 for the second detector. It also used the 2A5 output tube. AVC was derived from one diode in the detector which was driven by the plate signal of the second IF amplifier. The audio signal was generated by the second diode, operated from the secondary of the third IF transformer.

Model 447 did not include silencing. That function was marginally available from the sensitivity switch but it was not a quality inclusion. The set did incorporate a tuning meter, the Shadowgraph. The device was a meter-like instrument that partially interrupted a light beam that shone in a window in the escutcheon panel. When the station was properly tuned-in the plate current from the mixer and the IF amplifier tubes was at minimum so the vane in the Shadowgraph which was actuated by the sum of these currents made the narrowest shadow. This was best tuning for a reasonable interference-free station.

The tuning range for Model 447 was larger than any previous Atwater Kent radio. Its four bands were: 0.54 to 1.6 MHz, 1.6 to 4.5 MHz, 5 to 12 MHz and 12 to 22.5 MHz. The problem experienced in earlier sets that tried to tune above 15 MHz was caused by a too-big tuning condenser, was solved in the Model 447. In that set, the sections (gangs) of the condenser were divided by having two separate stators. The stators were switched by the band switch so that for the broadcast band and the two lower short-wave bands both stators in each gang were connected to the resonators. For the top short-wave band only one of the stators in each gang was used. That meant the coil could be a bit larger and its Q (quality) was increased along with its selectivity and dial discrimination.

Model 447 was a compact with its companion console identified as Model 577. They both used fan dials that revealed the scales for each band in window the shape of an arc. The band switch knob, through a system of levers and slides, moved the correct calibration scale for each band into the window. The fan dial escutcheon was fastened to the front of the Model 447 chassis. Surrounding it was either a cut-out in the front panel of the cabinet to which the Model 447 was to be mated or a rectangular finished panel which in turn, filled a larger hole in the console cabinet. This kind of arrangement assured that the Model 447 chassis could be fitted to several different cabinets with only the minor detail of finding the exactly right adapter panel.

Model 487 was the same radio as Model 447 with one large exception, it did not have four bands, It had only three and tuned only up to 16 MHz. There was also a minor difference, the AVC was applied to the mixer by way of the signal grid, where on Model 447 the mixer was not controlled by the AVC signal.

MODELS 318, 308

Model 318, Figure 90, was Model 447 with a push-pull output stage. Model 318 used two type-2A5 pentodes biased to operate in Class A. It was capable of producing about six watts audio output. The input to the push-pull stage was a transformer that was driven by the triode section of the type-55 second detector. (Model 447 used a type-2A6 tube for the second detector; the high-mu triode section was necessary to provide enough overall sensitivity in Model 447). With the input transformer and the push-pull tubes in Model 318, the detector triode did not have to have as much amplification so type 55 was an acceptable choice.

Model 318, like Model 447, was built with a three gang tuning condenser. Each gang was divided into two segments. On the broadcast band and the two lower short-wave bands both segments were connected for tuning. On the top short-wave band only one segment in each gang was used. This was done to increase the amount of capacitive reactance in the resonator especially at the high end of the top band, 22.5 MHz. The result was better tuning control and better rejection of unwanted signals and noise. Model 318 included a sensitivity control that could be used to change the amplification of the first IF stage. The sensitivity control was used to reduce the signal size on some of the larger broadcast stations. The tuning system also included a Shadowgraph tuning indicator that was operated by the plate currents of the mixer and the two IF amplifiers. The radio was housed in a modern console with a fan dial. The bands were selected by a knob to the right, under the tuning knob.

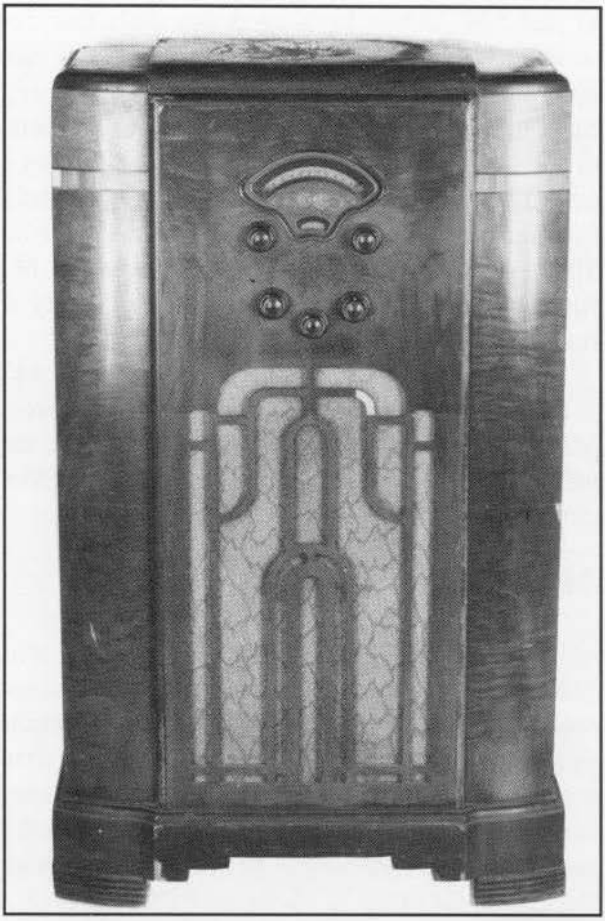


Figure 90.
Model 318. Kent's engineers designed a very fine medium-size chassis receiver. It covered the short waves, delivered moderate power, and presented a fine appearance in the living room.

Model 308 was a Model 318 that was built for the European market. Model 308 differed from Model 318 in having a long wave band instead of the low short wave band. Different parts of the world made use of different parts of the radio spectrum for their national radio transmissions. A radio manufacturer had to meet these differing requirements if he wanted to maintain his image an increase his sales. Kent, among others, provided the short-wave and the long-wave bands because of the European use of these frequencies. Similar radios sold domestically did not have such extensive coverage. The long-wave band provided on Model 308 was an example of patterning a radio for the needs of a particular market. Another example of equipping radios especially for a different market was that Europeans liked to listen to records. Therefore, like other sets that were shipped abroad, Model 308 was fitted with terminals for connecting a gramophone and a switch to make that selection.

MODELS 768Q, 978Q

Model 768Q, the compact and its companion radio Model 978Q, the console were four-band, short-wave radios that embodied nearly all of Atwater Kent's experience in radio design up to 1934. Both sets used the same chassis. The sets were operated by batteries, using a two volt air cell for the filaments and four 45-volt dry batteries for the plate voltages and bias. The 22½ volt tap on the first 45-volt battery was tied to ground so that the plate supply was about 157 volts. The plate voltage on the second and third audio amplifiers was about 145 volts.

The antenna signal was coupled to the resonators in the grid of the mixer stage. The band switch changed both the antenna coupling coils and the grid coils on all bands and the variable condenser on the high band. Mixing was done by a type-1C6 pentagrid converter to produce an IF of 472.5 kHz The second detector was a type-30 triode that developed the audio signal from its grid and used its amplification to develop the AVC. AVC was applied to the mixer and to the two type-34 tube IF amplifiers. Audio was amplified by a second stage and fed to a pair of Class A type-30 triodes. The only feature the set lacked was an RF amplifier.

The chassis was the large medium size that carried the three gang tuning on the top and the coils and switches underneath. The sections of the tuning condenser were dual with both sections used on all but the top band. The set was equipped with a sensitivity switch and a tone switch but did not have a tuning indicator. The dial was the big fan with a two-speed drive.

MODELS 206, 206D, 376, 376D

Model 206, Figure 91, was the first of Atwater Kent's compacts to use the new 2A7 pentagrid converter tube which had been developed to reduce the cost of implementing the mixer/oscillator in a simple superheterodyne. The tube contained five grids between the cathode and the plate. The first two were designed to permit amplifier action so the tube could be used as the oscillator active element. Even though grid number two acted as a plate, it allowed enough electrons to flow past its wires to become a stream that could be modulated by the other grids in the tube. The next grid (#3) provided isolation so that grid number four could work like a signal grid and cause the incoming RF signal to modulate the electron stream. The result was that at the plate the two original signals (local and incoming) and their sum and difference were recoverable. The difference was the IF so it was selected by the IF transformer and amplified by the next stage.



Figure 91. *Model 206. This compact receiver was a good all-around performer. It had good tone, made a good appearance and was a friendly set in an average American living room.*

Applying the type-2A7 tube was not a difficult job from a mechanical standpoint. It went into the older mixer location with only a change of socket. It was not so easy to redesign the circuit electrically, because the performance of the oscillator section of the converter had to be relatively constant over the band of interest in order to maintain the conversion gain and the noise ratio. This took experimental verification in the laboratory. The problem of making the stage work efficiently was more complicated than just making one band work.

Model 206 was a three-band radio. The bands were 540 kHz to 1.6 MHz, 1.6 MHz to 5 MHz, and 5 MHz to 15.5 MHz. Adjusting the coils, couplings, tube operating conditions and piece-parts that were temperature sensitive components required excellent engineering and model-shop fabrication to establish a stable design that the factory could effectively reproduce. Adjusting the set to be stable and sensitive was more difficult on the high end of each band than at the low end. It was even more difficult on the highest band. The reason was that oscillator section of the pentagrid converter produced smaller waves in the electron stream as the frequency increased. (Some communication receivers used a separate oscillator tube because of this difficulty at frequencies above 20 MHz). The IF was 472.5 kHz. Therefore, low band images were not as bad as on earlier sets. However, high band images were difficult to eliminate, and tracking was one of the difficult problems Kent's engineers had to solve.

Model 206 included an RF amplifier, a single IF amplifier, both using type-58 tubes, a second detector type-2A6 and the output tube that was used to replace type 47, the 2A5. The type-2A6 second detector

was a double-diode, triode. It differed from the type-55 that had become common because the amplification factor of its triode section was a little more than ten times higher.

Both AVC and audio voltages were derived from the diodes in the type-2A6 tube that were paralleled. In what had become almost standard at this time for later Kent's sets the AVC went to the RF and IF amplifiers and the audio went via the potentiometer, volume control to the triode of the detector.

The cabinet for Model 206 had a rounded-top, not flat as with some later sets and not a semi-circle as with Model 90. It had straight sides, a plainly figured grille and four knobs arranged in a straight line under the grille. The set was the first to be equipped with a new small chassis, in this case twelve inches wide by only six inches from to back. This smaller dimension was enough for the three gang tuning condenser and the tubes and transformers. Model 376 was the same chassis used in a console. Kent had found that customers bought radios for two reasons: the descriptions of performance and the appearance of the cabinet. They did not seem to react strongly to a small chassis in a console if the radio performed well. Hi-fidelity sound was not an important consideration.

Tuning calibration was laid out on a three band airplane dial, It was a circle about three inches in diameter mounted on the front apron of the chassis. In effect, it increased front-to-back dimension of the chassis to six inches. The dial itself was a matte-finish, buff colored, plastic disk with calibrations for all bands printed in dark brown. The dial was illuminated by two pilot lights, one for the top half, lit when the set was switched to the high short-wave band, one for the bottom half, lit alone for the low short-wave band and both for the broadcast band.

Models 206 and 376 were also manufactured for use on dc mains. They were the D versions. There were several important changes. The tubes in the RF and IF amplifiers were changed to the 6-volt equivalents, type 78. The mixer was changed to type 6A7 and the detector was changed to type 85. The reduced gain of the DC set was made up by using two type-43 pentodes in the output. All the filaments were connected in series with each other and in series with the loud-speaker field. The extra tube was located where the rectifier in the ac version had been.

The power transformer in the ac version was replaced by a filter choke that was located in the same place on the chassis. The choke was placed in series with the plus side of the line. When the set was plugged in to the mains there was an even chance that it would be backwards. On earlier sets, e.g., Model 82D, a lamp was lit to notify the owner. There was no indicator of polarity on this set (and others made at about the same time). If, after a few minutes, the set was quiet, the owner reversed

the plug. To avoid damage to the filter condenser from reversed polarity, a special non-polarized condenser was used.

MODELS 356, 286

Models 356, Figure 92, and 286 were brought out late in the model year that was led by Model 206, 1935. Because the technology of designing superheterodynes had moved fast, it might be supposed that the later set would show major improvements over the earlier one. This did not happen. The circuit for Model 356 used the same tubes with the same interconnections, the same transformers and the same operating conditions.

There were two differences, the chassis size and the dial. Model 356 used a chassis about one inch deeper from front-to-back than Model 206. The extra inch was used to ease the manufacturing techniques in wiring and to mount a different mechanism for the airplane dial that was similar to that on Model 206.

By 1934 Kent's engineers had established a set of design blocks for their different circuits that, like building blocks, enabled the factory to produce new radios having particular features without having to completely redesign each new radio. Comparing Model 356 to Model 206 by identifying the blocks nicely exemplifies this engineering practice.

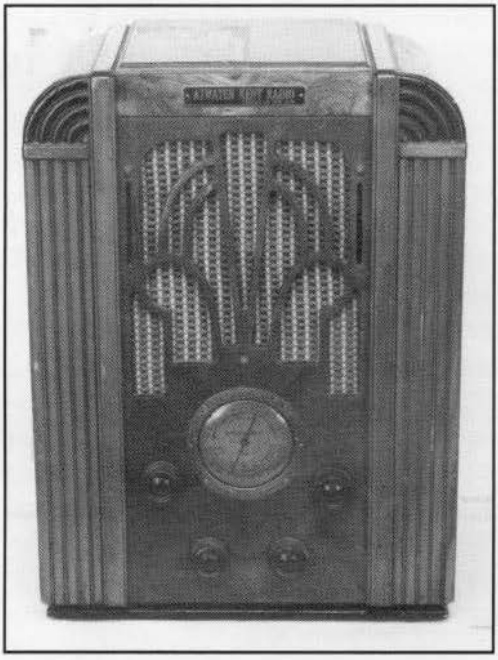


Figure 92. *Model 356. Combining the flat top and the rounded top led to the shouldered style. The popular six-tube-radio design with an airplane dial made this a very attractive set, especially when the fluted columns were added.*

Model 206 used 2.5 volt tubes with which Kent's staff had good experience. They had upgraded to the 2A- series of tubes (2A7, 2A6, 2A5) and found them economical and reliable. Kent's people had been worked hard to get good local oscillator performance with tubes that came before the pentagrid converter and had established satisfactory (internal standard) circuitry for broadcast and short-wave mixers but were glad to adopt the pentagrid converter. The double diode, triode had almost completely displaced the earlier forms of the second detector circuit and again, was the building block of choice. For the output circuit, the pentode had proven its worth with the type-47 tube so there was no reluctance in using the updated version, type 2A5.

There were more building blocks that could be used. Model 356, and its companion console Model 286 used another block, the RF amplifier. Other blocks that were not used were: The second IF amplifier, the push-pull output stage, a tuning indictor, Silencing, the fan dial (Mr. Kent's favorite), the super chassis and the segmented tuning condenser.

At the time that Model 356 came out, other Kent Radios were manufactured with 6-volt tubes. Why was Model 356, with its year-old design put on the market? One reason was that the Model 206 was so popular that a new set, dressed a little differently but with the same performance, could harvest the market. This would be a response to customer demand. Another reason was to put a set, less expensive to manufacture, into the competition. Because the electrical design was a simple reproduction and the performance parameters, including test, were already known, the main costs would have been the mechanical design, factory tools and dies, the cabinet and the dial. Assembly was not a new procedure, so little factory retraining was needed. Kent's manufacturing cost on Model 356 might have been less than three-quarters of his cost on Model 206. The companion console Model 286 would have benefited from this same cost saving.

Review of the way that engineering was done in Kent's Company and study of the production methods that he had in place, force the conclusion that he was technically well equipped to continue through the depression. But, one area that this study does not address was the impact of changing customer taste and capability to pay for the quality of Kent Radios. Kent's sales organization struggled hard to maintain the factory volume, taking advantage of the appeal of new tubes and better listening programs, with only marginal success. The next six-tube radios differ from the foregoing sets largely in the change to newer-style tubes that was a response to the customer rather than a technical foot forward.

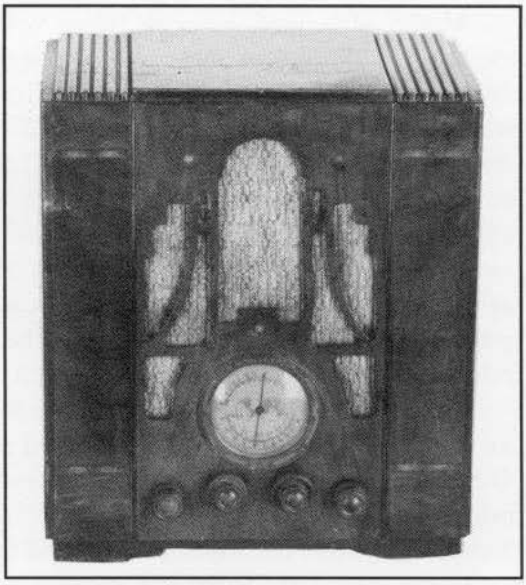


Figure 93. *Model 145. The squared top became a new style in the early 1930s. It cost a few cents less to make but it was not as space efficient as the rounded top. The airplane dial added a modern touch.*

MODELS 185A, 145, 325, 475, 735

Model 185A was the first of the Atwater Kent five-tube compact superheterodyne radios to use the new pentagrid-converter tube, type-2A7, for the active element of the local oscillator and also for converting that signal to an IF that tracked with the incoming signal. The tube was called pentagrid because it had five grids located between the cathode and the plate.

In the pentagrid converter, the first grid was usually used as the grid of the oscillator and the second grid was used as the plate. The third grid was a screen that served to generate a virtual cathode between itself and the next grid. The fourth grid was called the injection grid and was the element that modulated the electron stream with the incoming signal.

The fifth grid was sometimes called a screen grid and operated to serve as an accelerator at which time it was connected to a higher voltage. It was connected internally to the third grid. The signal grid (number four) was wound with variable turns spacing, which provided a remote-cutoff function and permitted the converter to respond to AVC. Kent did not use this capability in the early five-tube sets built with the type-2A7 tube in 1934 (185A, 145, 325) but did change the design for the later sets, the 475 and the 735.

Functionally, Model 185A was the same as Model 165. It tuned the broadcast band and another band immediately above the broadcast band. The choice of bands was provided by a rotating switch that also enabled

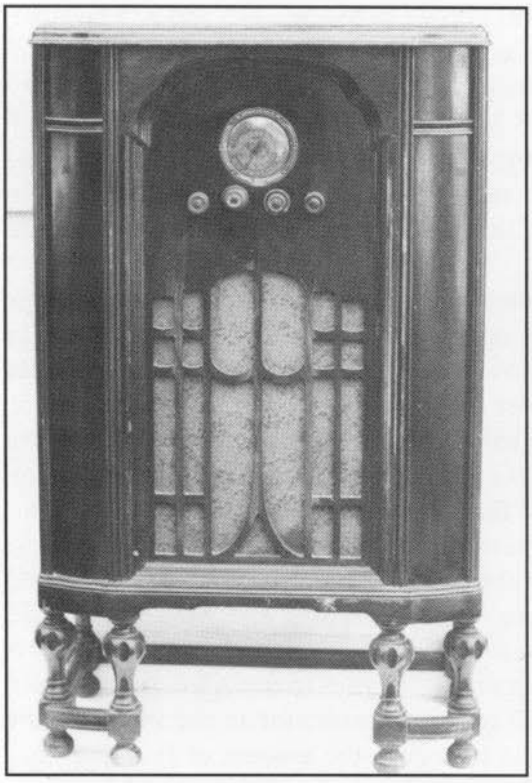


Figure 94. *Model 325. The earlier legged-console style dressed with an airplane dial differentiated this radio and let sales treat it as a new, improved set. It was still a five-tube radio with moderate performance.*

the listener to switch a condenser across the plate circuit of the audio amplifier in the type-2A6 second detector. The coils for the RF and oscillator resonators were tapped with the tap switched to ground through the band switch.

The bigger change of Model 185A from the earlier sets was the circuit for the local oscillator. The feedback function for the oscillator was provided by two coils in the anode circuit, the second grid of the mixer. No longer was the cathode involved in the feedback function. It was maintained at zero ac potential by its bypass condenser. The cathode ac voltage at zero was needed when the mixer function implemented AVC but Kent's engineers had not gotten that far in circuit design.

The next two five-tube radios that had been designed to use the 2A7 mixer were Models 145, Figure 93, the compact and 325, Figure 94, the corresponding console. These two had the updated oscillator circuit and another change that upgraded their performance, a second double-tuned IF transformer. Although the newer design used the earlier IF, the second transformer improved the adjacent channel rejection and the audio bandpass. The circuit at the diodes of the second detector was arranged to feed the AVC diode from the primary of the second transformer and the audio diode from the secondary.

Improved IF performance was needed in Models 145 and 325 because the set had been redesigned to cover two short-wave bands instead of the partial coverage of the police band that had been offered earlier. The new bands were 1.6 to 4.8 MHz and 5.3 to 16 MHz. Selection of either of these bands or the broadcast band was made by the band-switch, which connected three sets of coils to the three-section tuning condenser. The design retained the double-tuned RF circuit between the antenna and the mixer.

Models 145 and 325 presented the three-band frequency range on a buff-colored airplane dial. The upper band was shown as a semi-circle in the top half of the dial. The lower short-wave band and the broadcast band were presented in the lower half of the dial. Two pilot lights were switched with the band switch to illuminate the top half of the dial for the high short-wave band and to illuminate the lower half of the dial for the lower short-wave band. For the broadcast band, both the top and the bottom of the dial were illuminated.

There were two more five-tube radios that used the 2A7-mixer tube. These were Model 735, Figure 95, a compact, and Model 475, the console version of the pair. These two came out in late 1934. These two were the first of the five-tube superheterodynes to use AVC in the mixer stage. They also included an IF rejection resonator in the input circuit of the antenna. The function was to reduce the amount of IF signal that leaked out into the antenna and was radiated. The circuit had been used on some of the Model 185A production, but was not included in Models 145 and 325. Apparently, Kent customers had experienced some interference from the IF radiation so the factory devised a fix. It was tried on Model 185A but came too late to be included in the production run of Models 145 and 325. It was still a useful modification, so it was included in the next production run of Models 735 and 475.

MODEL 275

In 1934 there were still communities that were being served with dc house power. In some of the larger cities that had started with dc distribution the need to use electric energy that was produced some distance away had made the changeover to ac necessary to accommodate further expansion. There remained many buildings that had not been connected to utility power but had installed their own generating capability. All of these potential customers had to reject ac radios so there was a small but viable market for dc-powered sets. The older dc-only radios served, but for a manufacturer looking toward the future these were products whose time had passed.

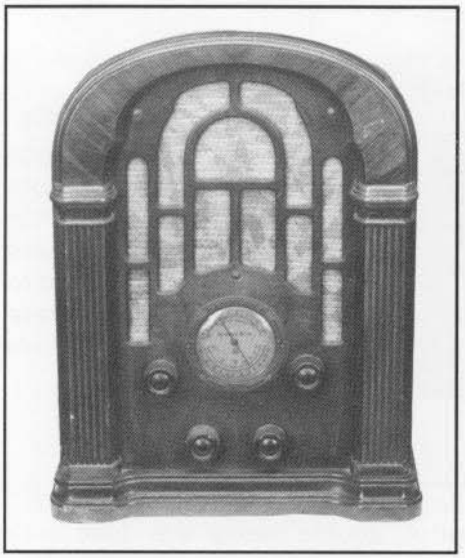


Figure 95. *Model 735. This flat-round-topped radio completed the styles for the middle range of sets. Its airplane dial gave it the thirties look.*

Tube manufacturers had developed the techniques of increasing the filament voltages of several tube types (and reducing the required current). It was well known that a string of filaments could be very usefully connected across a source, and efforts to connect a string in series across a power line had led to two new types, a rectifier and a power-output amplifier. These were type 25Z5, the rectifier, and type 43, the power pentode.

Combining the series string with suitable accommodation for both ac- and dc-power input led to a new family of small radios. Atwater Kent put three of these radios on the market. The first was Model 155, which came out in 1933. The other two were Model 275, Figure 96, in 1934 and Model 825, in late 1934 and/or early 1935. The designs of all three of these radios were similar. They were also directly derived from the five-tube, ac-powered superhets that were a main part of Atwater Kent's product line.

Model 275 was to be a set in which costs were reduced as far as the required performance would permit. With the type-25Z5 rectifier the power transformer was eliminated, which lowered plate voltage and reduced the maximum output volume and overall sensitivity. By selecting a higher IF (262.5 kHz) and retaining the IF amplifier, the sensitivity would have been adequate. Kent's engineers selected the type-44 remote-cutoff pentode for the IF amplifier. The 6-volt double-diode, triode detector tube, type 75 was available for AVC and audio detection in the second detector. Kent's engineers used the type-77 tube as both the oscillator and mixer. The incoming signal from the antenna was fed into the signal grid of the mixer to modulate the alternating part of the electron stream.

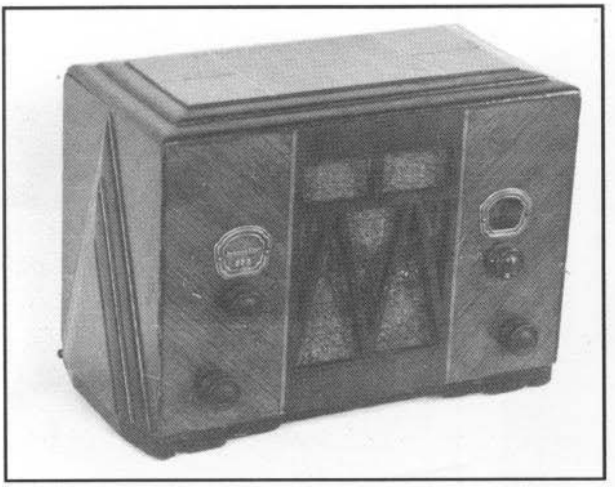


Figure 96. *Model 275. The impact of art-deco styling was not felt more strongly in any other Kent radio. This one was ac-dc and appealed to people of moderate income and with a taste for style.*

To keep image responses under control, double tuning was done in the RF circuitry between the antenna and the mixer. Another closely related activity was going on in the development of tubes. This was the addition of control elements (grids) to produce a tube especially suited to this service, the pentagrid converter. This tube was not available at the time of Model 155.

The power-supply portion of the radio took some careful circuit design. Required were rectification and filtering of the ac input, pass-through of the dc input, reverse plug protection, field exitation for the loud-speaker and bias for the output tube. These requirements were met by using the type 25Z5 in a doubler circuit on ac, and using only one half of it on dc. The field coil of the loud-speaker was used to filter ac but was switched so that on dc a part of it was fed from the type-25Z5 tube in parallel with the circuitry part of the set. No filtering was needed from the field coil of the loud-speaker when the set was operated on the dc mains, but bias was obtained from a tap on the field coil winding.

Model 275, the second of the ac-dc sets came out in 1934. The radio was very similar to Model 155 but had five changes. It used a type 6A7 for the mixer/oscillator function instead of the type-77 tube. The oscillator circuit was therefore changed to use the first two grids of the mixer tube as the active elements of the oscillator. The second grid acted as the plate and the first grid was connected to the oscillator frequency-determining resonator. No longer was the feedback coil used in the cathode circuit.

The third change was to tap the two input circuit-resonator coils to provide a short wave band. A switch was provided to select either the full coils for broadcast or the tapped coils for the band from 1.5 to 3.0 MHz for police listening. The IF was changed to 264 kHz, more for uniformity in production than for a specific advantage in performance.

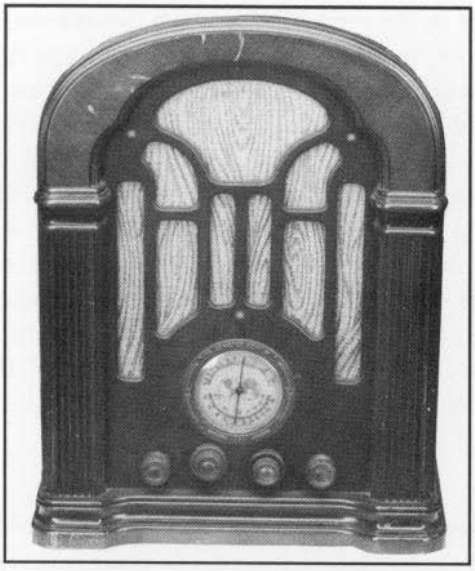


Figure 97. *Model 465Q. The battery-radio market continued strong in the early 1930s, and Kent built several models each year. This one with the modified top curve was a good performer and very popular.*

Model 275 was equipped with a tone control, a switched condenser at the grid of the output tube. Model 155 did not have the tone control. Because of the band switch and the tone-control switch, Model 275 had four eight-sided knobs while Model 155 had only two rounded, molded knobs.

MODELS 425 and 665

Models 425 and 665 were two more consoles that Kent offered in 1934. The same chassis was used for both consoles. Its design was electrically similar to earlier five-tube consoles and compacts. One difference was in the use of the type-2A6 tube as the second detector. Another difference was in the separation of the band switch from the tone switch, which led to an improvement in styling. These consoles were equipped with four knobs instead of three. The station selections showed through a window over the tuning knob.

MODELS 465Q AND 655Q

Model 465Q, Figure 97, the compact and Model 655Q, the console, were a companion pair of moderately priced battery radios. They were built on the small chassis, with a three-gang tuning condenser operated with an airplane dial. The set was built with three short-wave bands that ranged from .54 MHz to 16 MHz. The IF of Models 465Q and 655Q was 264 kHz. This was not high enough to eliminate the interference from large-signal images. Reducing those images in a set without an RF

amplifier required another resonator in the circuitry between the antenna and the input of the mixer. To accomplish this image reduction, one of the three resonant tuning circuits was coupled into the antenna circuit. Because it was tuned over the broadcast band only, it was not effective on the short-wave bands.

The mixer was a type-1C6 pentagrid converter. It was coupled with a double-tuned IF transformer to a type-34 pentode amplifier, whose output fed the type-32 detector. Volume was controlled by varying the screen voltage on the IF amplifier and the mixer. The output of the detector was fed to a type-30 triode amplifier which was the driver to the output stage, a type-19 tube operated in Class B. With 135 volts of B battery, the radios produced good volume with moderate input signals.

MODELS 135Z, 215Z

Models 135Z and 215Z were two of a total of four products that were built for people who had 32-volt electrical systems in their houses or farms. The letter "Z" in the model number signified the application to 32-volt dc power. The systems were usually powered directly from Edison-cell batteries. A simple gasoline engine, usually one cylinder, drove a generator to charge the batteries. In some systems the charging generators came on automatically when power was used, such as turning on a light. Other systems were charged by the owner when the batteries had been partially depleted. One of these systems suppliers was Delco; a whole series of appliances, along with several lights of different outputs were available for use on the 32-volt systems. The radio market for this application was small, but city people who had Atwater Kent radios at home were interested in having another Atwater Kent radio for their vacation and summer homes. This prompted Kent to make them.

For Kent and his staff, the design and production of 32-volt dc radios was not a difficult task. By mid-1934 the circuits for the radio itself were standard. They had been developed from the five-tube radios that were the bulk of Kent's production. A power supply design was available from the vibrator systems that Kent produced for automobile radios. A power transformer with a 32-volt primary, instead of the 6-volt winding used for automotive use, and a vibrator with a 32-volt coil were all that was required to power the Z sets. Rectification of the high voltage, using a type-84/6Z4 tube, was the same for both source voltages after the filament-dropping resistor was selected.

The circuit chosen for Models 135Z and 215Z was a three-band short-wave set that tuned from .5 to 16 MHz. It did not have an RF stage but did have an extra resonator in the antenna circuit for the broadcast band. The mixer tube was a type 6A7, the 6-volt equivalent of the 2A7 that Kent's engineers were using on nearly all the sets that were current at

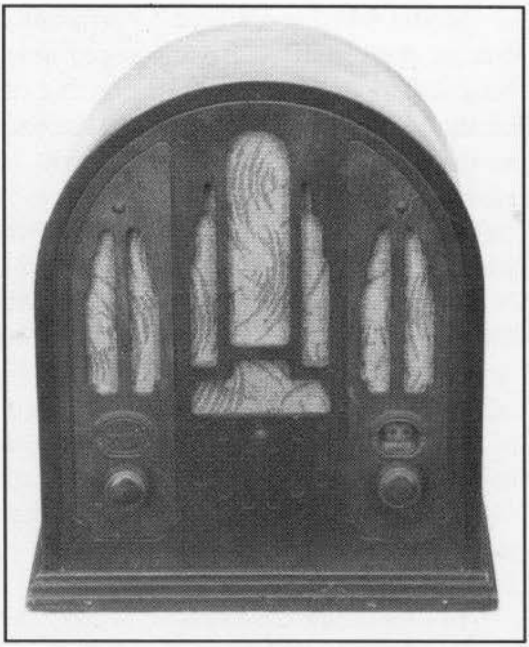


Figure 98. *Model 944. To carry on the tradition of Model 165/185, Kent brought out Model 944. It was expected to do the same job with one less tube, but was marginal in performance.*

the time. The IF at 264 kHz was amplified by a type-78 pentode with double-tuned input and output transformers. The detector was a type-75 double-diode, triode which developed AVC for the IF amplifier, and with a separate diode developed the audio signal across the volume-control potentiometer. The audio signal was fed through a resistance network to the type-43 output tube. Kent's experience with the ac-dc set made the design of the output stage an easy task.

The sets were equipped with airplane dials whose segments were lit by pilot lights to indicate the selected band. The top half was lighted for the high band, the lower half for the lower short-wave band, and both halves for the broadcast band.

MODEL 944

Model 944, Figure 98, brought out in 1934, was one of the three four-tube superheterodyne radios that Atwater Kent built. The other two, Models 854 and 184, came the next year. A superheterodyne of the time that Kent was in business needed, at a minimum, four functions, an oscillator, mixer, IF spectrum shaper and detector. Also, one or more vacuum tubes usually were included to act as amplifiers, and they were often accompanied by additional functions such as IF, RF and output amplifiers. Model 944 and its companions met the basic requirement for a superhet with two tubes, added a power-output tube and provided a power-supply rectifier, for a total of four. It was a complete superheterodyne radio, albeit the minimum entry for acceptable, general home use.

Model 944 used a type-57 pentode to generate the local signal by putting the circuitry for frequency selection in its plate circuit. Feed back was by inductive coupling to its cathode. This introduced the local-oscillator signal into the tube's electron stream ahead of the signal grid, so the input signal introduced at grid four further modulated the total electron flow. At the plate, the oscillator resonator selected the oscillator signal, and the double-tuned IF transformer selected the frequency which was the difference between the oscillator and the incoming frequencies. No separate IF amplifier was used in Model 944 (or the other two sets.) The IF was fed from the IF transformer to the signal grid of the second detector, a type-57 tube. There the IF signal was amplified and because of non-linear operation of the tube, also partially detected. At the plate of the detector the IF was fed back to the double-tuned IF transformer using a third winding to provide IF signal regeneration. The desired signal (the modulation of the incoming wave) was extracted from the plate circuit of the detector by a low-pass audio filter and fed to the output tube.

By operating the type-57 second detector tube in the regenerative mode, enough amplification was obtained to make up for the lack of a discrete IF amplifier. While this method could have been used in other Atwater Kent designs, the lack of sufficient IF-frequency discrimination (spectrum shaping) that resulted from the use of only one transformer tended to nullify the advantage of eliminating the IF-amplifier tube. Using two transformers, separated by the amplifier, resulted in a radio that had substantially better adjacent-channel discrimination. In a location where only two or three big stations, separated by several tens of kilohertz, were the only interests, Model 944 did a very acceptable job.

The IF of Model 944 was 450 kHz. An IF in this range meant that close images did not exist as they had in earlier sets with IFs near 130 kHz. The need for two RF tuning resonators was reduced, so Model 944 was built with only two sections in its tuning condenser. One section tuned the circuit between the antenna and the input of the first tube, and the second tuned the local oscillator. If the location where the Model 944 was used did not have a station right on the image frequency of the desired station, Model 944 did well. At the time that Model 944 came out there were no big stations operating above 1.4 MHz, so the entire broadcast band was image free from broadcast images. The band next above the broadcast band had police and aircraft assignments, so there was potential image interference from these stations, but these were easily eliminated by wave traps.

The output of Model 944 was provided by a type-2A5 pentode feeding a typical Atwater Kent electro-dynamic loud speaker. In most of the radios produced by Kent in 1934 and 1935, the volume control was

connected in the detector circuitry. In the Model 944 the volume control was located in the antenna circuit. The signal from the antenna was connected to a potentiometer whose arm controlled the level of the input to the radio. The quality of the output in an interference-free location, with good input signal levels, was as good as any other five-tube Kent set. However, Model 944 could not respond to varying signal levels because it was not equipped with AVC. In 1934, this was a significant disadvantage for general-coverage broadcast radios, but for the listener who left his radio tuned to only one station the disadvantage was not apparent.

MODEL 273D

One more superheterodyne deserves to be considered in the ac-dc group although it was not a proper member. That is Model 273D, an almost legendary Atwater Kent radio. *Rider's Volume Seven*, page 7-26, gives the circuit for Model 273D. Comparing it to the ac-dc sets suggests that it was derived from their designs. It used battery tubes, substituting the type-1A6 for the type-6A7 mixer, with a type 34 substituted for the type-44 IF amplifier.

A pentode is shown on the diagram for the detector/output tube and labeled as type 34. A small sketch of the chassis calls for a type-32 where the second detector had been in the ac-dc sets, with the legend below the sketch calling for the type 32. This conflict was partially resolved by the fact that a type-32 tube is a tetrode, not a pentode as shown. Power for the set was taken directly from the dc mains. This was, in effect, the dc operation of the ac-dc sets.

The circuit for the set shows headphone output from the detector tube. Three sketches, near the bottom of the drawing, show different ways of connecting multiple sets of headphones. A type-34 tube was not intended for audio service but it would have powered several sets of headphones adequately. The chassis sketch shows cancelled tube markings. These were typical of Models 275 and 825. However the knobs on the chassis sketch and the arrangement of the double resonators between the antenna and the mixer were characteristic of Model 155. It might be supposed that the chassis came from one of the later sets, and the cabinet for Model 273D was a rework of model 155.

What was the purpose of the radio? One explanation goes back to the crystal set that Atwater Kent built for the Philadelphia Naval Hospital inmates in 1923. At that time he made the Crystal Set available as a public service to patients in the hospital. With the advance of the radio art, a much more capable radio was needed for the same service in 1934. Perhaps this was the set he made for the men confined to life in the hospital.

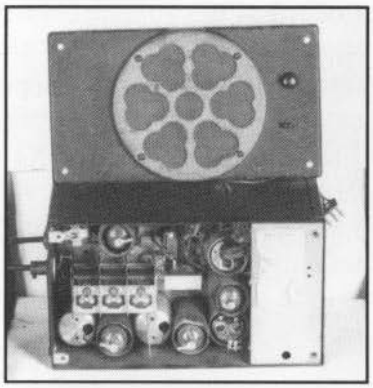


Figure 99. *Model 666. This 1934 auto radio was less powerful than the others of that year. It was a single unit tuned by a head connected to the steering column.*

MODELS 816, 926, 936, 666

In 1934 Atwater Kent produced four models of automobile radios. From the identification and exact configuration standpoints they were separate. From the design of the electronic circuitry three were identical and the fourth was very close. The three that had the same circuits and layouts were Models 816, 926 and 936. All three had RF amplifiers that used type-39 pentodes, and all three had IF amplifiers that used the same tube. The mixers were type-6A7 tubes and the detectors were type-85-tubes. One diode provided AVC for the amplifiers and the other diode developed the audio signal across the volume-control potentiometer. The triode section of the detector drove two type-41 pentodes that were operated in Class B.

All three radios used the control head to tune and adjust volume. Model 816 used a synchronous vibrator for converting 6-volts dc to 200 volts for plate power. The other two, Models 926 and 936, used the motor-generator system, called a Genemotor, which had been introduced on Model 636 a year before. Models 926 and 816 included the Genemotor and the loudspeaker in the same chassis as the radio. Model 936 included the Genemotor with the chassis, but provided a separate loudspeaker and enclosure.

The fourth automobile radio for 1934 was the Model 666, Figure 99. Its mechanical configuration was very similar to the other three, and it used the same control head for tuning and volume adjustment. The electrical circuitry was only a little different, mostly because it used newer tubes, the type-6D6 pentodes, for the IF and RF amplifiers. The other difference was the use of a single type-41 pentode for the output instead of the push-push pair. The power supply was different, using a simple vibrator to interrupt the primary current in a transformer that fed a type-84/6Z4 rectifier. In this the power supply was almost a duplicate of the one in Model 135Z. The difference between the two was the input of 32-volts dc for Model 135Z, as compared to 6-volts dc for Model 666.

Chapter 19

THE 1935 SERIES

1935 was, for Atwater Kent, the end of the big-chassis era. Circuit development had moved to the point where efficient designs could be achieved with no more than eight tubes, while more tubes were used to provide frills. (Today they're called bells and whistles.) Radios that were built with more tubes tended to be specialties and were not usually high-volume production sets. Kent did not want anything to do with a specialty shop. For him, a specialty shop was a valuable charity but it was not a direct part of his business. The result of going to big-chassis sets, with tube counts above ten, for major production companies like Atwater Kent was a money-losing conflict between the limited customer base and the cost of keeping a factory working. Up to 1935 the cost of producing the big-chassis sets was defrayed by the high-end appeal. The middle-level sets had to carry the engineering and the costs of creative redesigns.

The middle-class market for radios was well served by five- and six-tube sets. Kent's engineering had developed and recorded all the technology associated with quality production of this class of radio receivers, and no more development was either needed or justified. This put Kent into the position of simply reducing costs and turning the crank. The radio-manufacturing business that he built had changed from imaginative to hum-drum.

The low-end market had nearly stabilized on ac-dc, four- or five-tube radios that were produced by people who were more interested in cash flow (into their pockets) than new radio designs. They understood the nature of cheap radio production and were committed to that business. The wholesale prices for the sets got as far down as five dollars. That was not a market that would support Kent's factory and certainly not his approach to radio as a means of bringing culture to the listener.

With only the middle market as a viable business in 1935, and with no technical challenge, Atwater Kent and his technical staff must have been looking for other ways to use their capabilities. Getting into the communication-receiver field or trying to produce transmitters involved very big changes for the factory and its customer base. Making a factual, detailed cost analysis may have been all but impossible, but an intuitive evaluation would have indicated a very difficult and expensive transition. Hallicrafters, Hammarlund and National were too strong for direct competition.



Figure 100. *The Kent Refrigerator. Kent tried a new line in 1935. He licensed the shelves from Crosley and built a quality machine.*

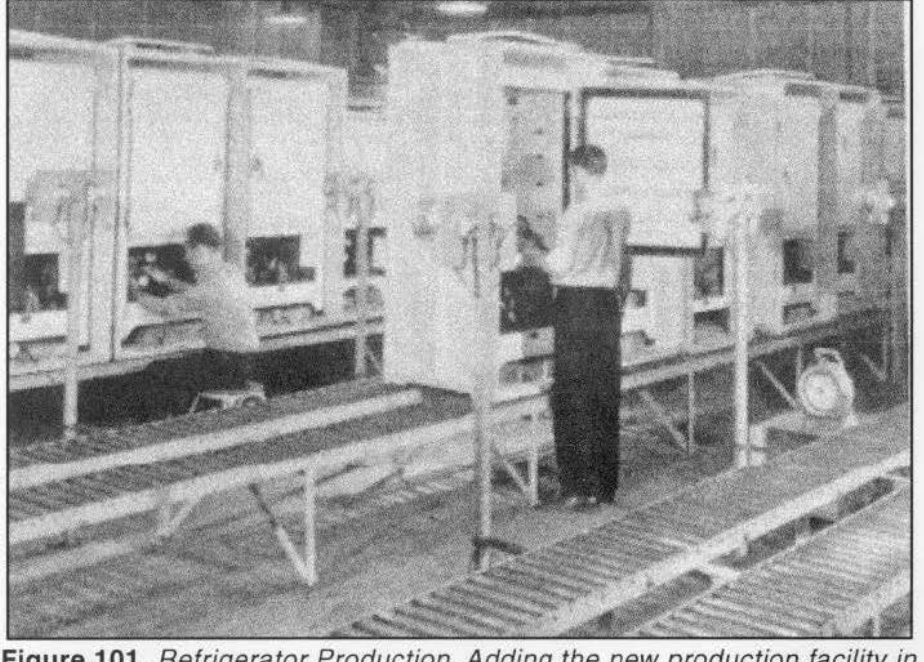


Figure 101. *Refrigerator Production. Adding the new production facility in the factory already skilled in radio production was but a small step. The much larger one was competing for sales.*

A different field offered a possible new direction; domestic refrigerators. The appliance industry considered radios, washers, ironers, big radios and refrigerators as major appliances, and Kent's people had some acquaintance with that market. They also had a very strong awareness of the potential customers. Kent's design group and his factory-process engineers had little difficulty in setting up a manufacturing line for mid-size home refrigerators, Figures 100 and 101. By early 1935 the Atwater Kent refrigerator was on the market. Unfortunately, the new product was not able to rescue the factory from the down side of the matured radio-manufacturing business.

Another way to extend the business was to expand the sales in foreign markets, The *1935 Service Notes*, and more directly the 1936 material, shows that the company made major efforts to open up the South American market and to expand shipments to Great Britain. Minor changes were required to make the American sets into compatible radios for the foreign markets. These were modifying the input-power supply for 230 volts and changing some of the tuning bands for short-wave reception in the particular area where the sets were to be sold. Some of the radios, particularly the smaller sets, were assembled and shipped as complete units. Some of the more expensive sets were exported as chassis to be installed in a cabinet made in the new country. Sets destined for foreign markets were identified with a terminal letter. "E" was used for the European market, and "X" was used for sets to go to South America.

In the material that follows the terminal letters are indicated with the Model number. Other lists give them separately but the changes to the sets for foreign markets did not alter manufacturing. Their main effects were in sales and shipping. The 1935 and 1936 radios are combined in a single series in the following descriptions, because the data does not lend itself to easy identification of the model year. Where the date of initial production is known, it is indicated in the text.

MODEL 710

Model 710 was one of the last console radios made by Atwater Kent. It seems to date from late 1935, and tuned the broadcast band and three short-wave bands. The IF was 472.5 MHz, the highest that Kent used. The stages were an RF amplifier with a single tuned circuit between the antenna and the type-6D6 remote-cutoff pentode, a mixer using a type-6A7 tube with the local oscillator taking the first two grids for its active elements, two IF amplifiers using type-6D6 tubes arranged with double-tuned transformers for input, output and inter-stage coupling; and the second detector using a type-6B7 double-diode pentode. The two diodes

were connected together to rectify the IF signal for both AVC and audio.

The tuning condenser on Model 710 had three sections, each divided into segments. For the broadcast band both segments were used to tune all the connected coils (RF, oscillator and mixer). On the short-wave bands, one segment of each section was switched out. On the high end of each band the resulting capacitive reactance was larger, so the Q (quality) was higher and the frequency discrimination was better. The set could tune to frequencies above 22 MHz with dial spaces that were still useful in logging stations. In Model 710, each of the IF transformers used at the input of the IF amplifiers was arranged with an extra winding on its core. With this switched into the secondary of the transformer the bandwidth was increased. This would have served to improve the audio high-frequency response of the radio, and was therefore used on the broadcast band. In the other position of the tone switch, the transformer had a narrower bandpass and would have worked well for short-wave listening, because in those days, 1935 and 1936, the short-wave stations that were received in the United States did not have enough signal strength for high-quality audio listening.

The audio signal was developed by the diodes of the type-6B7 tube across the volume control potentiometer. From there it was amplified by the pentode section of the tube and fed, by way of a complex tone network (similar to that in Model 112), to a pair of type-76 triodes. These tubes were operated in Class A, push-pull, to drive a pair of type-45 output tubes. This was the only set (except for the radios in the 70 series and earlier) to use these tubes in the output. Type-45 tubes, operated in Class AB, delivered about 15 watts of output. Model 710 was a competitive radio; it had all the features that were demanded by the listeners of the mid-thirties.

MODEL 810

Model 810 was one of the best reputation-building radios for Atwater Kent. His electrical designers included the features that experience had proven to be most popular, and his stylists presented a very effective complement to the appearance of the upper middle-class American living room. The radio had one more very good feature, but it was not one that Kent even imagined. Model 810 was a survivor, lasting in obscurity and then reappearing with a new-found popularity after more than sixty years. Although Model 810 was a console that took a lot of museum space, it became a set that today's collectors welcome. Model 810 was similar in its RF and IF configuration to Model 710 but it was one step

newer. It was the first ten-tube Kent receiver to use octal tubes. The RF coils, the band switches and the tuning condensers were the same in both sets. In Model 810, the RF amplifier was a type-6K7 pentode whose grid circuit was tuned. For each band, the resonator had its own switched-antenna-coupling coil. Between the RF amplifier and the injection grid of the mixer there was a resonant circuit for each band, with its own coupling coil connected to the plate of the RF amplifier.

The mixer tube was a type-6A8 pentagrid converter. Signal injection was by means of grid #4. Grids #1 and #2 were used by the local oscillator to generate the mixing input. The IF of 472.5 kHz was amplified by two stages of type-6K7 tubes and used double-tuned transformers. Taps on the secondaries of the inter-stage and the output-IF transformers were switched to provide broad and sharp bandpasses. The broad selection was identified by the term fidelity.

Signal and AVC were recovered from the IF in the second detector, a type-6H6 double diode with the two diodes tied together. AVC was fed back to the RF amplifier via the coils of the broadcast band. It was fed to the first IF amplifier for use on all bands. Plate currents from the mixer and the first IF amplifier were used to operate the tuning meter, a Shadowgraph.

Audio was fed to a compensated volume control, and from there to the grid of the first audio amplifier, a type-6F5 triode. Tone control was switched in the grid and the plate of this amplifier. The output of the first audio amplifier was resistance coupled to the second audio amplifier, a type-6F6 pentode, which developed enough power to drive the output amplifier. The output of the second audio amplifier was coupled through a split secondary transformer to a pair of Class AB type-6F6 tubes. Model 810 was capable of an output of about 15 watts with a strong input signal.

MODEL 312

Model 312, the 6-volt filament version of the All-Wave radio, was, in many ways, an updated Model 112. The type-58 tubes were replaced by 6D6 tubes in the Model 312, and the type-56 tubes in Model 112 were replaced by type-76 tubes. There were three other differences. The local oscillator and the mixer tubes of the Model 112 were replaced by a type-6A7 pentagrid converter, the second detector was replaced by two type-76 triodes, and the audio network was replaced by a simple switched-condenser tone control.

Model 312 used 6-volt filament tubes, except in the output stage, where the 2A3 triodes were retained. That was a good move for two reasons. There was no extra cost involved, because in all the sets with

2A3 tubes a separate filament winding was provided for them. The second reason was that there was no 6-volt power triode equivalent to the 2A3. Redesigning the output for available 6-volt tubes would have defeated the purpose for which the Model 312 had been brought out (simple substitution of 6-volt for 2.5-volt filament tubes.) The power-supply rectifier was changed from the workhorse type-80 that had been used ever since Atwater Kent gave up his own, No. 609, to a 5Z3, a higher current full-wave tube.

MODEL 412

Model 412 was another radio in the series that started with Model 112. It was also a 6-volt tube set like Model 312 but the tubes were octal based. The type-6D6 tubes in Model 312 became type-6K7 tubes in Model 412, and the type-76s went to 6C5s. The type-6A7 was replaced by its octal version, type 6A8. The type 2A3 output tubes were again used in Model 412.

The difference in the circuitry of Model 412 was in the second detector. The diode rectifiers used in the earlier sets were replaced by a type-6H6 double diode, with the two plates tied together, as were the two cathodes. The tube was used as a single rectifier, which produced both the AVC voltage and the audio signal. AVC was used on the first IF amplifier and on the RF amplifier for the broadcast band only. The Shadowgraph tuning meter on Model 412 was operated from the plate current of the first IF amplifier and the mixer. Model 412 also use the 5Z3 rectifier in its power supply.

Whether Model 412 was ever widely distributed in the United States or not is an open question at this time. Letters seem to accompany all designations of the set, "P", "E", and "X". On the Rider's page for the circuit diagram (AK 7-35) the Atwater Kent printing adjacent to the phono switch reads "Radio Gramo", indicating a foreign distribution for the set. The letter "E" meant European and usually was accompanied by a power transformer that could be operated on 230 volts, as was the case with Model 412 where there were two primaries. The letter "X" was used to indicate a 230-volt power input. The Model numbers in Rider's are P412, E412, P412X and E412X, and both European and South American distributions are suggested by those model numbers.

MODELS 648, 608

Model 648 was built in the transition time when Atwater Kent went from the tubes in the 2.5-volt heater series to their counterparts in the 6-

volt heater series. Model 648 was almost the same radio as Model 318. The tubes were, of course, the biggest difference. While the pinouts were the same, and the functions were the same, the two radios differed substantially in the customer's mind. The type-58 tubes used in the RF and two IF amplifiers were changed to 6D6. Type 2A7 in the mixer went to type 6A7, and type 55 in the second detector went to an 85. The output tubes changed from two type 2A5s to two type 42s.

The second significant difference was that the Model 648 incorporated only two short-wave bands instead of the three which had been part of the excellent coverage of Model 318. Because the highest frequency reached by Model 648 was near 16 MHz instead of the upper limit of 22.5 MHz in Model 318, its three-gang tuning condenser did not have split stators. Model 648 used the highest IF that the Kent sets had reached, 472.5 kHz, even though it was not as necessary as on Model 318. The third change was in the addition of some European features to Model 648. Gramophone terminals were made available on the rear apron of the chassis. There was no switch to select a radio program or a record. Instead the terminals used a jumper to open the cathode of the second IF amplifier when the gramophone was used, or to let the listener lift the pickup when the radio was wanted.

Another feature was a switch that let the listener select either "high fidelity" or "selectivity." The switch connected two small coils, one to each secondary of the double-tuned IF transformers. The coil detuned the transformer slightly, broadening its spectral response. Model 648 and Model 608 were equipped with fan dials that had windows to show the action of the Shadowgraph tuning meter, which was operated by the plate currents of the first three tubes in the radio, RF and IF amplifiers and the mixer. The input power for Model 648 and Model 608 was another feature that identified the radio as being produced for the European market. The power transformer was built with two primaries so that it would be compatible with regular European power-distribution systems.

MODELS 649, 349

Model 649, Figure 102, was the most complete little-chassis radio that Kent made near the end of his production period. It was also almost the last full-functioned radio that he produced. The set used octal tubes, but it was almost the same set as Model 648 (except for the tubes). The tubes were the octal equivalents of the glass series. Model 649 was also very nearly the same radio as Model 328. The difference in the tube count between Model 648 and Model 649 was not in the number of output tubes (both had two output tubes) but in the way that the second detector

was configured. Model 648 used a type-85 double-diode, triode, and Model 649 used a double-diode 6H6 and a 6C5 triode.

Like Model 328, Model 649 was a console, and in some radio sets was offered with the same console cabinet as Model 328. Its companion, possibly a compact set, was Model 349. (*Rider's* simply lists 349 as: "Same as Model 649".) Model 649 incorporated nearly all the blocks, with the same values that were used in Model 328. It added another output tube, a type 6F6. The two were operated in push-pull with a maximum output of about six watts. The other change was the audio amplifier. It was changed from a type 6F5 to a 6C5, which was a better tube for driving the push-pull 6F6 output tubes.

Model 649 incorporated the Selectivity/Fidelity circuit, the Shadowgraph and a tone circuit that permitted the listener to switch one of three condensers across the input to the output stage. With the IF at 472.5 kHz, the two IF stages, the RF stage and the type-6A8 pentagrid converter, the Model 649 was an excellent radio, and a credit to Kent's people.

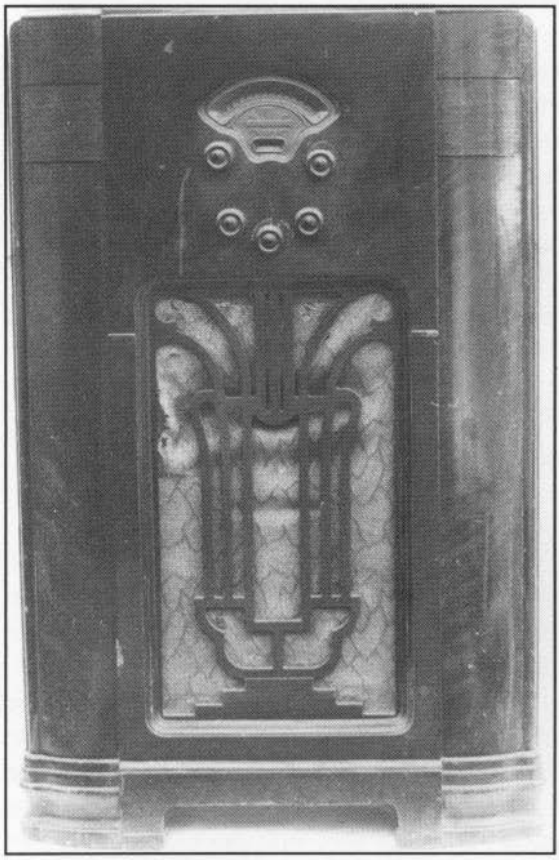


Figure 102. *Model 649. Toward the end of Kent's radio business, he produced this top-line set. It was sold in foreign markets and was also put out in a phonograph version.*

MODELS 208, 248

Model 208 was another late Atwater Kent radio that was built predominantly for European service. It was never identified in Kent's domestic service manuals. Its diagram in Rider's Volume VII, page 7-19, was not a Kent drawing, suggesting that the set was identified by Rider's engineers from Kent data received after Kent stopped his manufacturing operation. More clues to the lateness and the uniqueness of Model 208 are that it used all octal tubes, but got rid of the 6H6/6C5 combination by using a type-6R7 double-diode, triode. Otherwise the tube line-up is the same as in Model 649.

MODEL 168

Determining when Atwater Kent produced a radio for the foreign market is sometimes very difficult. A case in point is Model 168. The tubes that were built into the radio suggest that the it was built at about the time of Model 188. This is borne out by the big chassis, which was used for some eight-tube sets built in 1933. It is further indicated by the 125-kHz IF which was typical of the sets built for Europe, and the two range bands. The negative argument, that the set was produced after 1933, is made by the fact that the model number is not listed in the Atwater Kent Service Manuals, and only appears in Volume 7 of the *Rider's Manuals*.

The form of the Rider diagram with the tube symbols done in black with white elements is clearly a drafted product of Atwater Kent's engineering service, but it is of the later generation. Earlier diagrams used white tube symbols with black elements. It has been suggested that the files in the Wissahickon Avenue plant had many diagrams that were not published by Kent. They were made available after the plant closed and were published by Rider, mostly in Volume 7. This diagram seems to have been updated from the type-1 schematic toward the end of the time the engineering force had time to work on drawings, perhaps in 1935.

The Model 168 was a combination of the design of Model 188 and Model 588. Instead of the single broadcast band of Model 188, this radio had two bands and used the complex band switch of Model 588. It used type-58 pentodes for the RF and IF amplifiers and the mixer. The local oscillator was a type-56 triode and the detector was a type-55 double-diode, triode. The audio was transformer-coupled into the final stage, two type-47 pentodes operated in Class A. The power transformer for the set used a dual primary typically connected for 230-volt operation.
The radio had AVC derived from one of the detector diodes and a form of silencing. This was a variable bias control in the cathode returns of the

RF and IF amplifiers that could be set to partially disable the AVC action. This system was not as effective as the use of the silencing tube, but the overall appeal of silencing was problematic anyway. It was more of a sales appeal than a necessary automatic function for the general listener.

In the partial parts list that Rider published for this radio, the set is clearly identified as a European console. One conjecture is that the set was built late, intended to use an early but satisfactory design and parts that were still available in the factory. It would have been a profitable set, and especially if the cabinet was provided at the point-of-sale by a European manufacturer.

MODELS 317, 337, 200, 637, 717

Toward the end of the Atwater Kent Manufacturing Company's active radio business metal tubes were developed. These tubes no longer used glass for their envelopes, instead using a precisely shaped steel cylinder. By this time the design of radio receivers had been standardized on an arrangement of eight pins that eased the assembly and wiring of receivers. The last line of radios that Kent produced for the American market took advantage of these improvements in tube technology to try to enhance their image and their sales volume.

Model 456 was the six-tube set in the line. It was a rich looking compact with a small chassis and a multicolored airplane dial. Its circuit used a type-6A8 for the mixer/oscillator and a type-6K7 for the IF amplifier. At the time of the set's design an octal double-diode, triode had not become available, so Kent's engineers used a type-6H6 for the diodes and a type-6F5 for the audio triode amplifier. A type-6F6 output tube and a 5Z4 rectifier completed the tube line-up for Model 456.

Model 317 added a 6K7 RF amplifier to the circuit of Model 456 to make the new seven-tube receiver with octal tubes. The three-band capability, broadcast, low short-wave 1.7 to 5 MHz, and high short-wave 5.5 to 18 MHz; and the 472.5 kHz IF were carried into Model 317. The extra winding in the output IF transformer of Model 456 was also used. The result was a radio with more sensitivity, good band coverage and typical Atwater Kent quality and appearance.

Model 337 was the companion console set to Model 317. It had the same chassis, including the airplane dial, but did not have the color in the dial. Model 200 was another set that used the Model 317 chassis. It was built for European distribution so it had terminals for a gramophone. Model 637 and Model 717 were also users of the Model 317 chassis. It must be noted that the number that went with the compact, and which went with the console, was not clear to the author. More research is needed to establish the relationship.

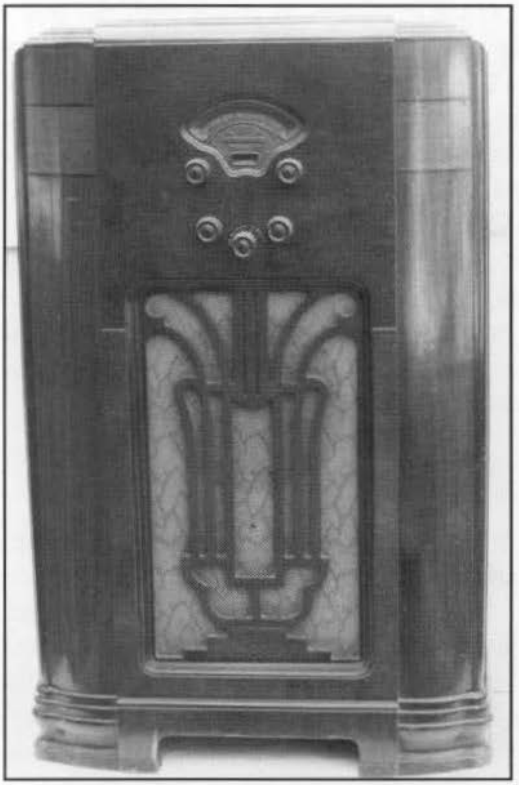


Figure 103. *Model 328. Eight tubes were right for providing a sensitive radio with short-wave coverage and good quality output. The Shadowgraph" tuning indicator in the fan dial was the deluxe touch.*

MODELS 328 AND 828

Model 328, Figure 103, was the next step up in circuit complexity from Model 317 for radios that were equipped with the new octal tubes. Model 328 took all the blocks that were parts of Model 317 and added a second 6K7 stage of IF. It also removed the Model 317 feedback tie from the second IF transformer to the screen of the IF amplifier tube. Model 328 offered a fidelity-selectivity function by bringing out an extra winding from the input IF transformers (at the grids of each of the two IF amplifiers) to a switch, and using them to slightly detune the transformers. This had the effect of broadening the IF pass-band when the extra coil was connected and narrowing the pass-band when the coil was switched out.

Model 328 did not use the airplane dial. Instead, it was fitted with a three-band fan dial. The calibrated part of the dial was arranged on a vertical track so that it slid up and down under the pointer as the different bands were selected. The radio was also equipped with a Shadowgraph tuning indicator whose window was located just below the fan part of the escutcheon.

The AVC action of Model 328 was produced along with the audio signal across the volume control potentiometer by one of the two diodes of the type-6H6 detector tube. (The second diode was connected across the AVC line, but doing nothing with the negative AVC voltage. AVC was used on the RF and first IF amplifiers and the mixer. The plate currents from the first IF amplifier and the mixer were used to operate the Shadowgraph. (The Shadowgraph action is explained in the review of big-chassis set Model 788 et seq.).

A Model 828 was listed in *Riders Index*, but the reference given was for Model 328. This set was probably another European model with special features such as the power transformer or the frequency coverage. More research is needed to locate and describe this Model 828.

MODEL 825

Model 825 was a reissue of the Model 275 ac-dc radio that Kent brought out in 1935. No features were added or removed, and the differences were in the restyled cabinet. A close comparison of the circuit diagrams indicates that the same master was used for each drawing. The details of the RF-coil layouts were removed from the Model 825 drawing and the title boxes were changed. This is a very strong indication that no more investment in the ac-dc radio family was to be made by the Atwater Kent Manufacturing Company.

MODELS 545, 755, 875, 765, 865

Model 545 marked Atwater Kent's changeover of the five-tube, no RF-stage superheterodyne radios from 2.5-volt heaters to 6-volt heaters. The tubes types that had been proven effective in 1934 were replaced by the corresponding new styles. The 6A7 replaced the 2A7, the 6D6 replaced the 58, a 75 replaced the 55 and a 42 replaced the 47. No circuit changes were necessary to accommodate the new tubes, and not even mechanical changes such as tube sockets had to be changed, although the identifications did have to be changed.

Model 545 was typified by three changes. The first was the tube substitution, the second the moving of the IF to 450 kHz, and the third the reduction of the tuning circuits between the antenna and the input of the mixer. Moving the IF up meant a better capability to reject IF image frequency. With the 450 kHz IF the image was 0.9 MHz above the incoming frequency. This took advantage of the input-tuning circuit's capability to reject, but it did not entirely replace the rejection capability of the double-tuned circuit.

The remainder of the Model 545 design was similar to earlier five-tube superheterodynes. It used an airplane dial with two bands, the broadcast shown in the lower half and the 2 to 7.5 MHz short wave band in the top half. The general design demonstrated further cost reduction by the designers, including the simple flat-topped cabinet which was adequate but plain. The Model 755 compact and the Model 875 console were a pair of five-tube superheterodynes that were built late in 1935 for the overseas market. Atwater Kent's marketing people were very actively pursuing exports to keep the factory going and made sure these two sets were the best of the Kent sets at the time. They utilized all the improvements that had been developed over the previous three years of five-tube superheterodyne production. Models 755 and 875 were equipped with a special Radio/Phono switch and a terminal board for connecting a pick-up. The switch disabled the IF amplifier and connected the pick-up to the volume control in the "Phono" position. Power transformers for these two radios had dual primaries, to be used on 230-volt ac-power systems, but they could also be used on 115-volt systems.

Double-tuned IF transformers were used in the input and output circuits of the 6D6 IF amplifier. The type-75 second detector was used to develop an AVC signal, which was used to modify the amplification of the IF stage and the conversion gain of the 6A7 mixer. The input circuit, along with the local oscillator, provided three bands, with broadcast and short-wave coverage up to 16 MHz. The RF tuning used double-coupled coils that used two sections of the tuning condenser, with the third section assigned to the oscillator. To assure minimal radiation of the 264 kHz IF signal, these two sets used an IF wave trap in the antenna circuit. This circuit was developed at the time of the late Model 185A, and incorporated in Model 735 and in Model 475.

There were two more five-tube superheterodyne radios that used the six-volt pentagrid converter. One was Model 765, an interesting combination of Models 545 and 755. From Model 545 Kent's engineers used the two-section variable condenser and the associated coils. From Model 755 they used the dual-primary 230-volt ac-input. A minor change from Model 545 was a further increase of the IF to 472.5 kHz, the value that had become standard on the later Kent radios. The second was Model 865 that used the octal version of the converter, the type-6A8.

Kent's designers tried another variation in the application of the double-tuned IF transformer that was connected in the output of the IF amplifier stage. It was to place another coupling winding on the transformer core and connect it in series with the screen of the amplifier tube. This, it was felt, provided a more linear response from the amplifier. Model 765 did not enjoy a widespread popularity in the United States. One reason it was obsolescent at the time of its introduction was that octal

tubes had been put on the market, and sales of a set with tubes that were only identical to the latest octal tubes collapsed. The radio with the octal tubes as direct replacements for the older tubes was Model 865, but like Model 765 it was manufactured for the European market.

MODELS 435, 255, 225, 535, 725

Model 435 was the same radio as Model 545 except for its tubes. The type-6A7 had become a 6A8, the 6D6 had become a 6K7 and the 42 had become a 6F6. The second detector, a 75, and 80 rectifier were not changed. The performance of Model 435 did not change from that of its predecessor, but its appearance did. Both the Model 435, the compact, and its companion set, Model 255, the console, were fitted with airplane dials. The set had two bands, broadcast from 0.54 to 1.7 MHz and short wave from 2.3 to 7.5 MHz. The dials were similar to the earlier dials but did not have the feature of lighting different sections for different bands.

Model 225, another compact with an airplane dial, was introduced along with Models 435 and 255 to offer a higher short-wave band. It tuned from 3.9 to 12.6 MHz. The short-wave performance of Model 435 was not effective enough to compete in the foreign markets, so Model 535 and its companion Model 725 were brought to the market. Their upper band tuned to 18 MHz. The international market for radios was profitable but a little difficult to directly incorporate into the domestic operation. Kent had an extensive sales force in Europe and South America. He supplied the radios and chassis that were current in the United States but they were usually slightly different because of power and coverage differences. Their model numbers were more in keeping with their own markets, but were traceable to the domestic data that was necessary to service them.

MODELS 336 AND 216

Model 336 was the 6-volt version of Model 356, reviewed above. The Model 316 console version incorporated the same tube changes, updating from the Model 386 reviewed earlier. The mixer/oscillator went from type-2A7 to a 6A7. The RF and IF amplifiers changed from type 58s to 6D6s. The second detector was changed from a type 2A6 to a 75, and the output tube from a type 2A5 to a 42. The type-80 rectifier was not changed. Model 336, like Model 356, was a six-tube, three-band short-wave and broadcast radio. It had an RF amplifier, one IF amplifier, AVC applied to the RF and IF amplifiers and a two-light airplane dial.

Kent's engineers added one circuit modification to Model 356. The change was adding a winding on the output IF transformer and connecting

it to the screen grid of the IF-amplifier tube. This circuit application was also made on the Model 765 five-tube set that was current at the same time.

MODELS 456, 676, 856, 976

Six-tube radios were assembled from several combinations of circuit blocks. They included more or fewer capabilities, depending on the blocks that were selected. Model 356 was a typical five-tube receiver (mixer/oscillator, IF amplifier, second detector, output amplifier and power rectifier) with an RF amplifier added. Model 456 was a different combination. It was a five-tube radio without the double-diode, triode tube, but used separate tubes for these functions. The double-diode part of the second detector was fulfilled with a 6H6 octal tube. The triode audio amplifier was a 6F5 octal triode. The mixer/oscillator was the octal-based converter, a 6A8. The IF amplifier was a 6K7.

For the first time in the Atwater Kent series of receivers, the power rectifier, which until 1935 had been the faithful type 80, was replaced with its upgraded octal version, a type 5Z4. The reason was to make all the tubes in the set members of the octal style. This was not a necessary technical requirement. It may well have come from the need to announce and advertise the set as a new, modern, octal-based-tube radio.

Model 856 and its companion Model 976 were equipped with buff-colored, three band airplane dials. Their short-wave coverage went to 18 MHz. They were wired with the same IF feedback winding that was used in Model 356, a part of the second IF transformer and connected to the screen grid of the IF amplifier. The 6F6 output tube that was first used in this six-tube set was an excellent replacement for the early type-47 tubes and the later type-2A5 tubes. It could supply slightly more power with a little less distortion.

Model 456 and its companion console set, Model 676, were the same radios as Models 856 and 976. The differences were in the airplane dials, which that gave the sets a richer appearance. The segments of the dial calibrations were colored so that when the pilot lights indicated the band of choice, the set cast a color into the darkened area where the set was located.

MODEL 236

Model 236 was the last of Atwater Kent's six-tube radios. This set was actually another five-tube radio, but it was neither octal-tube equipped nor did it use a pentagrid converter tube for the mixer/oscillator. It

was a two-band radio with double-tuned RF circuitry between the antenna and the mixer input. The mixer was a type-58 tube and the oscillator was a type 56. The oscillator resonator was coupled inductively to the input resonator of the mixer. Coupling was effective for the broadcast band and the low frequency short wave, but that system was not effective for applications at frequencies above 20 MHz.

The question arises about why a set produced near the end of Kent's production did not use the tubes and circuits that had been developed over the years that his engineers had been working with superheterodyne circuits. One explanation relates to the market for Model 236. The set was built for the European market. There the pentagrid converter was brought into general service about two years after it had become the tube of choice in the U.S. The dealers would have had nearly no spares and would have been reluctant to invest in that kind of inventory. There would have been little customer demand for it.

MODELS 854, 184

Model 854 was brought out in 1935. Its design was almost identical to that of Model 944, and it used the same tube types to do the same functions. There was one difference; Model 854 was equipped with a tone control. It was a simple two-position rotating switch that permitted the listener to connect a small condenser across the grid of the output stage, thereby softening the higher audio frequencies fed to the output. Mechanically, the switch was placed between the other two controls, making this radio a three-knob radio where the earlier set had only two knobs.

Model 184 was introduced later in 1935. It was Model 854 with the 2.5-volt tubes replaced with 6-volt tubes. The first stage, the oscillator-mixer, was changed from type 57 to a 6C6, both sharp-cutoff pentodes. The second stage, the detector was also changed from type-57 to a 6C6. The regenerative connection of this tube, where its plate was fed back to the IF transformer, was changed slightly in Model 184 by adding a small variable condenser in that connection. Adjustment permitted maximum regeneration without the objectionable effects of ringing or spillover. The third stage, the output, was changed from a type-2A5 tube to a 42. The tone control was not changed, so the overall performance of the stage was not altered. An "X" version (184X) was produced in 1935 for sale outside the United States.

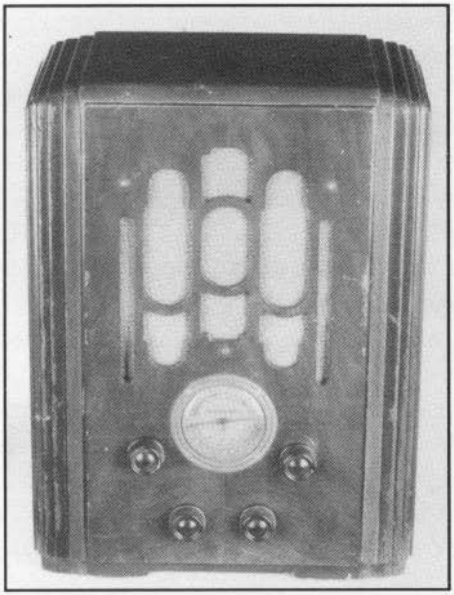


Figure 104. *Model 305Z. Many homes in the early thirties used 32-volt battery systems for lights and conveniences. Kent based this set on his auto-radio designs with up-to-date cabinetry to reach this market.*

MODELS 305Z, 565Z

Models 305Z and 565Z were the other two of the total of four 32-volt radios that Atwater Kent built for people with independent household or farm-electric systems. Models 135Z and 215Z were reviewed in the 1934 Series. The letter "Z" in the model number signified the application to 32-volt dc power systems. Those systems were usually powered directly from Edison cell batteries.

Model 305 Z, Figure 104, was a deeper compact than the earlier set, Model 135Z. The same was true of the console Models 565Z and 215Z. The extra depth was used for the deluxe tuning mechanism with its two-speed capability. The earlier set was not built to be an easy-to-tune set for the short waves above 5 MHz; its condenser drive did not give enough spread so great care had to be used to avoid overshooting a weak station. The more complicated dial on Models 305Z and 565Z let a listener move to a selected frequency in two steps. First one rotated fairly rapidly to a point close to the desired frequency and then, at a much lower rate, tuned in the exact value by ear.

For Kent and his staff, the design and production of 32-volt dc radios was not a difficult task. By mid-1934 the circuits for the radio itself were standard. They had been developed from the five-tube radios that were the bulk of Kent's production. A power supply design was available from the vibrator systems that Kent produced for automobile radios. The design of the 1935 set was little more than a review of what had worked well on sets like Model 206, and the minor modifications necessary to

drive. Another was in replacing the second IF transformer in the earlier Z sets with a double-tuned transformer.

The circuit chosen for all four Z Models was a three-band short-wave set that tuned from .5 to 16 MHz. It did not have an RF stage but did have an extra resonator in the antenna circuit for the broadcast band. The mixer tube was a type 6A7, the 6-volt equivalent of the 2A7 that Kent's engineers had been using up to mid-1935. The IF at 264 kHz was amplified by a type-78 pentode with double-tuned input and output transformers. The detector was a type-75 double-diode, triode which developed AVC for the IF amplifier, and with a separate diode developed the audio signal across the volume-control potentiometer. The audio signal was fed through a resistance network to the type-43 output.

The sets were equipped with buff-colored, translucent airplane dials whose segments were lit by pilot lights to indicate the selected band. The top half was lighted for the high band, the lower half for the lower short-wave band and both halves for the broadcast band. The dial was surrounded with an escutcheon that dressed the opening in the cabinet. Some Kent radios that came out in 1934, 1935, and 1936 had their model numbers coined in the escutcheon. Others, like the Model 305Z, were identified by the Model number on the top half of the plastic dial. Kent did not mark this set with the Z terminal letter. It was simply Model 305.

A power transformer with a 32-volt primary instead of the 6-volt winding (automotive application) and a vibrator with a 32-volt coil were all that was required to power the Z sets. Rectification of the high voltage was done with a type-84/6Z4 tube. The power supply was a small metal box (a little less than 8 by 8 by 3.5 inches) that could be included either in the radio cabinet or placed outboard. It was connected to the set by means of a five-wire cable. Kent recommend that different locations be tried to minimize hum and interference from the lighting plant.

MODELS 625Q and 385Q

The market for battery-operated radios in both the United States and abroad continued strong enough for Atwater Kent to produce several different styles during 1935 and early 1936. The eight-tube models from 1934 (768Q and 968Q) were continued. The five-tube series, that had started with Models 465Q and 655Q, was updated by increasing the depth of the chassis from seven to eight inches to accommodate the deluxe two-speed tuning mechanism, which had been developed to precisely select frequencies in the high band. The radios were enclosed in slightly different cabinets to appeal to listeners whose interests were strong for

different cabinets to appeal to listeners whose interests were strong for the short wave bands, but whose need for good performance on the broadcast band was less emphatic. Neither of these two sets nor their predecessors had AVC, so their capability to maintain reasonably constant output as they were tuned across their ranges was limited.

MODELS 657Q, 747Q

The features that had made earlier Atwater Kent battery radios popular; moderate sensitivity, short-wave range to 16 MHz, and attractive cabinetry were the basis of the next enhancement in Kent's Q series of radios. A prior lack of AVC was remedied by changing the detector from a type-32 pentode to a newly introduced type-1B5 double-diode, triode. The overall sensitivity of the radio was further increased and the IF band was more tightly controlled, by adding a second IF amplifier and using three double-tuned IF transformers.

For this radio the audio signal was taken from the volume control which was the audio-diode load. The triode of the detector amplified the audio and fed it to the type-30 driver stage. The output stage was a pair of type-30 triodes operated in Class B, driven by the inter-stage transformer that connected them to the driver stage. The radio was capable of as much as two watts of audio output power, but the capability to reproduce that much sound with good fidelity was limited by the loud-speaker, a permanent-magnet, moveable-armature unit.

In 1935 and 1936, the American market for battery radios of this capability had been replaced by utility-powered sets. There were still rural areas where utility power had not become available, but those areas were small and were being eliminated rapidly. The situation in foreign countries, particularly in the rest of the Americas, was different. There, the market for good battery radios was strong. Program content, especially on the short waves, was improving. The need to become more modern at home and to be more like the North Americans was making new Atwater Kent radios very desirable.

MODELS 237Q, 467Q

Model 237Q and 467Q were interesting combinations of technologies whose beginnings came from other experiences that Kent's engineers had with their work. Where the "Q" in the Model designator indicated a battery set, this pair did not get plate and bias voltages directly from batteries as did the tubes in other "Q" sets. These two sets instead had a power supply that was nearly identical to that found in an automobile

radio. The set might well have had a Z designator, but that was reserved for 32-volt radios. Since these two sets were the only ones with 2-volt filament tubes and a 6-volt source, perhaps there was not enough impetus to generate another designator.

These two radios were especially effective in meeting the needs of an isolated location. Their performance was excellent, but a more important feature was the lack of a need for dry batteries. They were battery sets, independent of the power lines, but able to work from the readily available power found on most farms, ranches and isolated businesses, which maintained vehicles that used six-volt systems for ignition and lighting. They therefore could keep a radio battery in good condition for after-work listening.

MODELS 415Q, 285Q, 515Q, 485Q,

The five-tube series of battery radios that had started with Model 165Q and continued through Models 625Q and 385Q had demonstrated that the market for five-tube, moderately-priced style of radio was alive, well and worth pursuing. Early in 1936 Kent's business was showing a different appearance. The size of the product line that was necessary to maintain the factory in a loss-free status had to be many times larger than the market for one of its better radio products. This conflict led to another one; when to shut down the business, versus what sets to upgrade to continue competing in the market.

Models 515Q, a short-wave compact and 485Q, its companion console along with Models 415Q, a broadcast-only compact and its companion, 285Q, were upgraded from the earlier members of the series at the end of 1935 for the 1936 model year. These radios were the last of the sets of this group to be redesigned and produced by the Atwater Kent Manufacturing Company.

Models 415Q and 285Q were equipped with a diode second detector that processed both audio and AVC. The tube was a type-30 triode connected as a diode (grounded plate) with a double-tuned IF transformer operating at 450 kHz. The IF indicates the radios to be intended for the European market. Audio amplification was provided by a type-32 pentode, fed into the type-33 pentode output tube. With the high IF, only a single tuning circuit was required between the antenna and the input to the mixer, so the set used a double-section tuning condenser and an airplane dial on a 5 by 12-inch chassis.

Models 515Q and 485Q were the last of the short-wave five-tube sets. They were minor redesigns of the earlier radios that benefited from several improvements in technology. One was the introduction of the type-1A4 battery pentode, an improved type-34 with slightly higher gain

with three double-tuned IF transformers in the new design, along with the better detector. AVC was used on the two IF amplifiers and the converter. The IF was 450 kHz, again indicating that the sets were intended for foreign rather than domestic sales. These radios were built on the 5 by 12-inch chassis with airplane dials. They covered three bands, this time extending the upper end to 18 MHz, very nearly the top of the performance capability of the 1C4 mixer/oscillator.

MODEL 776

Model 776 was the only automobile radio that Atwater Kent brought out for 1935. Nearly identical to Model 666 that had been introduced the year before, the tube line up was the same, two 6D6 pentodes for the RF and IF amplifiers, a 6A7 for the mixer, an 85 for the second detector and control tube, and a 41 pentode for the output. Both sets used a vibrator-transformer system for high voltage with a type-84/6Z4 for the power rectifier.

The IF of the sets used two double-tuned transformers operated at 264 kHz. It was high enough to permit two tuned-RF circuits to reduce images on the broadcast band to the level where, in automobile service, they were indiscernible. Both the Models used a speaker that was built into the cover of the main-receiver container. Model 776 was made available with a control head suitable for use on the steering column of the automobile. It also took one step further along in the growing incorporation of radios in cars, by offering a specialized control head. Mounting brackets and dress plates that could be fitted into the dash of the automobile were available for Ford, and Chrysler and Hudson products.

MODELS 126, 136, 416, 446, 556

In 1936 Kent offered another automobile radio. It had five variations, but the fundamental design was only a small step away from the Model 776 of the year before and the Model 666 of two years earlier. The main difference was in the updating of the tubes. Their functions were the same as in the earlier sets, but they were octal instead six and seven pins. Type-6K7 pentodes replaced the 6D6 tubes. The mixer was updated to a 6A8 and the second detector was changed to a 6Q7. The output in all the variations of this set was a 6F6 instead of the earlier 41 pentode, and the rectifier was changed to a 6X5.

The variations were an interesting combination of features whose main appeal was not so much technical as customer oriented. There was something for everybody. Sets numbers 126 and 416 were equipped

something for everybody. Sets numbers 126 and 416 were equipped with glass tubes. They were the same numbers as the metal tubes but carried the "G" letter. Sets numbers 136 and 446 were built with metal tubes. One glass-tubed set, Model 126, and one metal-tubed set, Model 416, were built with the loudspeaker in the cover of the main container. This design went back to Models 776 and 666. One glass-tubed set, Model 136, and one-metal tube set, Model 446, were each built with separate loudspeakers.

The fifth set in the series, Model 556, had neither metal tubes nor the separate loudspeaker. It was the least fancy of the series and did not have the tone control that was found on the other four. All of the five radios could power a separate loudspeaker for installations where that feature was needed.

Chapter 20

IN CLOSING

Atwater Kent's automobile radios present a brief picture of how radios were designed and factories were operated in the middle nineteen thirties. As can be seen by reviewing the sets for 1933 through 1936, the mechanical design did not go through major changes. Neither did the fundamental electrical design. As new tubes became available they were incorporated but their effects on performance were minimal. They were, in effect, the same electronic devices packaged in new containers, metal cylinders instead of glass envelopes.

The placement of radios in automobiles had become fairly standard. The main container of the radio was placed under the dash. The tuning controls were connected by mechanical and electrical cables to a tuning head fastened to the steering column or in the face of the instrument cluster. This was the part of the radio that the customer saw. The tuning mechanism, but not the rest of the radio, was customized for each automobile application and restyled from year to year. With enough volume capability and a quiet car, the loudspeaker placed under the dash was satisfactory. In more deluxe installations, an extra loudspeaker provided the more presence-oriented sound for discriminating listeners. The design, parts fabrication, and assembly of these radios had become so standard that creative engineering was no longer a part of the process.

Production of other styles of radios like the small table models and the smaller consoles had become just as routine. Almost no electrical engineering was involved, and the only difference was the appearance of the enclosure. Some mechanical engineering was required to modify the dies used for punching out parts and new chassis forms, but that work was better handled by contracts with companies that specialized in die-making. A busy factory like Atwater Kent's was a beehive of workers. Material handlers with hand trucks brought rolled steel plates to the presses. Others carried away the newly stamped parts. Still others delivered parts to the assembly lines for installation, wiring and soldering, Completed assemblies were moved to test and adjustment stations. Tubes were installed. Auxiliary parts and cabinets were accumulated. The fully finished radios were boxed, packed and finally delivered to the shipping dock.

Experience of the writer with similar manufacturing situations in other companies and with other products strongly suggests that proper engineering and manufacturing philosophies have always been to conserve capital assets and meet customer requirements using existing designs and tools to the greatest practical extent. The selection of new cabinet styles was done by the art department, which usually contracted with art studios for new designs that reflected the changing customer tastes. Purchasing then got involved to contract for cabinet production and delivery by furniture manufacturers who competed for the business.

The creativity was in choosing cabinet designs, not in production. Atwater Kent's role in the whole process of making radios was selection and approval. The days of anticipating and meeting customer needs by shaping the entire production process and building a national reputation were displaced by the idea of reducing prices and building market share. Kent had tried moving to another field, domestic refrigerators, but there was not enough challenge in that product line to make him want to build that business as he had done with radios. Although he was very protective of his name as a national radio maker, he was not interested in personal power over an expanding business. He kept his company going, but not for the power and profit that other men saw in being executives.

While it is tempting to suggest the Kent foresaw the end of the business and therefore lowered his sights, a closer analysis of his practices tends to negate that idea. The time that the last automobile radios were designed and the factory was tooled up for their production was in mid-1935, a full year before the factory was closed down. In 1935 and in the early part of 1936 Kent actively pursued foreign business and updated many radios for Europe and South America. That Kent anticipated the end of his company as early as 1935 and at the same time expanded his foreign sales doesn't ring true.

Atwater Kent was a realist. For him there was no longer the creative thrill of envisioning and inventing a new radio model. The market had become too static for his dynamic personality. It would appear that he was bored with what he was manufacturing but he was not ready to stop. He was of an age to retire; he had worked hard and in fact had given his life to his work, but he was ready to go. Although it was the time to relax, to spend his later years in a manner very different from his work, in short to play a little, Kent had to accustom himself to that new way of life.

Nevertheless the end was coming. Was it long anticipated or did it happen rapidly? While Atwater Kent may have looked toward the end for a year, the personnel in the factory did not have that prescience. For them, it came rapidly. As an example, the latest service manual insert for automobile radios was published in May of 1936, only a few months before the factory was closed.

Another example of the rapidity of the factory shutdown may be found in a review of the schematics and the data about Atwater Kent radios that may be found in Volume VII of the *Rider's* Series. Many of these diagrams were never published by Atwater Kent in his *Service Notes*. More startling, however, is the fact that some of the diagrams were not even drawn by Kent's draftsmen. It has been suggested, and there is more than a little basis for the idea, that as a result of an agreement between John Rider and Atwater Kent, the engineering data remaining after the factory was closed was to be to turned over tc Rider for publication. It appears that one or more Rider engineers made the trip from New York to Philadelphia and filled their suitcases (or even a trunk) with the remaining data in the Kent engineering files. Some of the data has been found in the Rider archives.

When Rider ended up with a master list of all the Kent radios and their variations, he would have tried to locate and publish all the schematics and data. Where a schematic was not in the Atwater Kent format, Rider's staff would have reconstructed it. Refer to *Rider's* Atwater Kent pages 7-29, Model 312 and 7-65, Model 710. Both of these sets were intended for the European market in 1935 and 1936, but were not available in the *Kent Service Manual* format. Perhaps the main data for these two sets was not retained in Philadelphia, but Rider's people captured the information and did their job. The sketchiness of the data handling suggests that Kent's engineering organization had been reduced from its earlier capability in the middle-to-late part of 1936.

Before the cycle of the 1937 models started, Atwater Kent accepted the end of his radio manufacturing work and closed the factory. He had been pushing at full force for forty years and had achieved an exceptional acceptance by other industrialists, the entertainment industry and the general public. For him, the world was no longer a comfortable place in which to create and build. From Atwater Kent Jr. we know that Mr. Kent closed the plant with little ceremony.

Atwater Kent Jr. had the task of disposing of the assets of the factory and then the buildings themselves. To today's historians this idea has a slightly odd sound. Today a multi-million-dollar factory would not be the responsibility of one man; he would have to share with stockholders, bondholders and others who had partial ownership of the business. The Atwater Kent Manufacturing Company was a different financial structure altogether. It was wholly owned by Mr. Kent and was fully paid for. Therefore when his dad told Atwater Kent Jr. to sell the factory, he was talking about their family assets and how they would convert their real property into other forms of wealth.

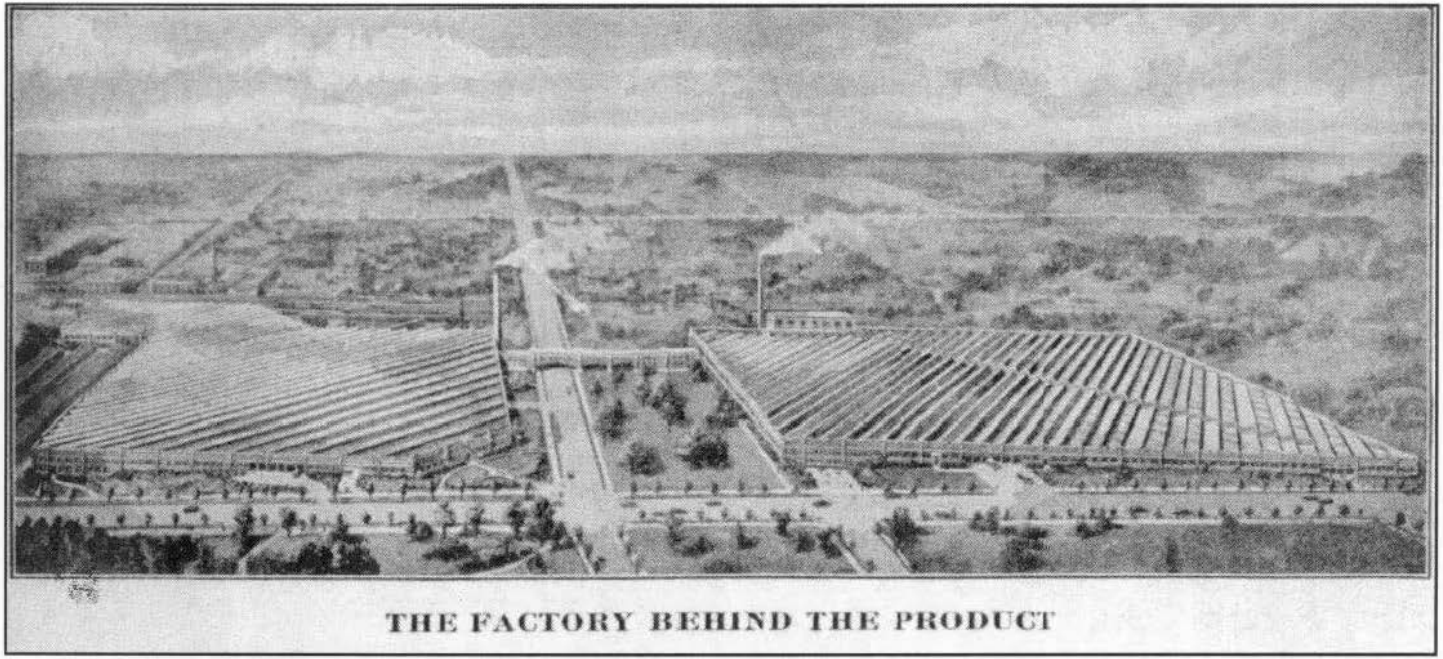


Figure 105. The Atwater Kent Factory. The factory on Wissahickon Avenue in Philadelphia looked like this from 1928 until 1998, even though it was no longer the home of the Atwater Kent Manufacturing Company.

The preparation for liquidation went rapidly. Figure 106 reproduces the front and page 56 of the brochure that the factory published when the liquidation was announced publicly. A part of the rear page is overlaid to show the time stamp of one of the recipients. Note that the stamp reads April 27, 1937. This was less than a year from the time that foreign and domestic shipping was in full swing. The document numbers 56 pages with lists of every kind of item in the factory. Some items suggest how big that factory had become: 2,969 soldering irons, 17,000 feet of overhead conveyers, 407 presses sized from 400 tons to a flat-edge trimming press.

Disposing of the buildings took longer. In 1938 American industry was preparing to support its allies in the oncoming European conflict (later Lend-Lease) so the superb Kent factory buildings were attractive to the electrical industry. Bendix became a part of the complex and so did Philco. After World War II the buildings were used by Health, Education and Welfare and by the Veterans Administration. Building Number 1 is still in use, Building Number 2, the right hand building in Figure 105, the one put in service in 1928, was removed in 1998 to provide more space for Veteran's Affairs whose office building was built adjacent to the Kent factory.

CONCLUSION

For some of us, the Atwater Kent story ended with the demolition of Building No. 2 to make way for a parking lot. For the factory employees, the story ended in 1936 when operations terminated. For museum people and collectors, the story continues. The reasons are to be found in the nature of Atwater Kent's business and the qualities of its founder.

The factory was part of the business. Its buildings were one element. Inside, there was another element, the production equipment. But the factory was also know-how and experience. And it was spirit and purpose. Its products were still another element of the business. They did not all terminate together.

Studying the factory, as well as the radios and the ephemera that still exist in collections everywhere, reveals the growth and decline of the business and how it reflected Atwater Kent himself. The factory and the radios grew with his enthusiasm and his drive and waned when he lost interest. The factory buildings were the most modem that could be built because that was how Kent wanted them, but their intended use was only as he needed them. He was not greatly concerned with the future. Nevertheless, Building No. 1 had utility far beyond him. It has remained in service for three-quarters of a century, more than six times as long as it was used by Atwater Kent.

Figure 106. *Sales Brochure. This is the cover (bottom) and one page (top) from the brochure that listed all of the factory tools and furnishing for sale when the factory was liquidated in 1936 and 1937.*

His radios were excellent in function and appearance because Kent understood his market and they have long survived their maker. His people were the best because they were the talent with whom he associated. His quality was the highest because that was his standard. But Kent did not see himself in the role of an educator. Although he enclosed a Time Capsule in the cornerstone of Building No. 2 (opened in 1998), it was more of a monument than a teaching artifact.

This review has tried to picture a small part of early twentieth-century industry, particularly as it relates to communications. It has portrayed a major business that is uncommon today, the personally owned corporation. Only such a corporation could be closed down at the decision of one man. Given the conditions of the depression year's and the limitations implied by the nature of his corporation, Kent's actions were probably the right course. Right or wrong, he left us with an inspiring heritage.

Atwater Kent has given us far more than he ever intended. We are indebted to him for his spirit and the artifacts that he left. His experience is ours to use and to incorporate in our studies and collections.

Appendix 1

Restoration of Atwater Kent Breadboards

Board Refinishing

Atwater Kent combined quality of manufacture with the predominant style. His instruments were therefore individually mounted with attractive subpanels and dials. Along with the instruments, he produced boards on which the instruments could be assembled. If the factory part numbers were assigned in time sequence, they indicate the boards were offered for sale shortly after the first instruments, and months before the radio assembly in the factory was initiated. The first board was No. 3061, 8½ by 18 inches; it was released about the middle of 1922.

Significantly, the boards were of highest quality, finished with the molded ogee curve on all four edges and with tongue-and- grooved end-pieces to prevent warping and checking. That style, continued for as long as Open Sets were made, is one of the main attractions for present day collectors.

When requests made by the Atwater Kent distributors for assembled sets convinced the factory to offer complete radios, it was typical of Atwater Kent to simply put together the instruments and the boards that he had been producing. The acceptance of the resulting radios encouraged the factory to continue development of circuits and performance, but to retain the characteristic Open Set style. They were produced for about three years, a long time in the rapidly changing conditions of the early twenties.

From the beginning, Open Set boards were made of solid mahogany with a varnish finish. While it is possible they were available in different shades of brown, no record of different board materials or colors exists. Collectors occasionally discuss how dark the original color was in comparison to the color as the board is found today. While some like a medium brown, the removal of the TA unit from a board that has never been refinished and which has not been hurt by the passage of time, shows a rich brown with a highly polished finish.

To restore a board to that finish over its entire upper surface, with the lower surface restored correspondingly, is a major task. Several steps are necessary: removing the instruments and wires; repairing gouges and holes; refinishing the surface; and rewiring with both old and new material.

The first step, removing the instruments is easy. Because many knurled nuts were used, some sets can be stripped with no need of unsoldering. On the later sets, the instruments were assembled with wires that were threaded through holes in the board and soldered to the underside wiring. To remove the instrument, its wires must be unsoldered from the main wiring. This brings up the question of coping with staples.

Atwater Kent used wire staples made of steel and coated with copper to secure the wiring on the breadboards. They, too, were carried over from the ignition business where they were used to secure some ofthe wires inside the wooden boxes that contained the high voltage transformers (coils). Removing the staples can be easy if they are loosened first. However, to their dismay, many collectors have found that pulling the staples out of the board directly (without loosening) is almost impossible. They will break off, leaving a buried end that makes replacement a mess.

By pushing the staple sideways along the wire it can be made to enlarge its holes enough to permit lifting it out with long-nose pliers. A screw driver whose end has been blunted, tapped with a light hammer, will do the job. Even better is a piece of steel rod filed to a "U" shape on one end, to fit over the wire and to bear on the arch of the staple. Remember, tap first in one direction along the wire, and then in the other direction, until the staple is loose.

After the staples for instrument connections have been removed, the instrument wires are unsoldered by stroking the joint with a hot iron and separating the wire from the main run with a plastic or wooden stick. To avoid damaging the board with the hot joint, slip a card underneath before applying the iron.

All the instruments should be taken off the board by removing their securing screws and lifting them carefully. Where the through-wires are enclosed with spaghetti tubing, try to save it, but expect to leave the part of it in the board hole. Most of the time the spaghetti is broken at the surface of the board. At this point in the disassembly some wires will be sticking up through the board. The remainder of the staples should next be removed. This will leave the underboard wiring free. It should be removed with as little unsoldering as possible. The terminal screws can usually be tapped out without unsoldering, but if they appear tight, use a high capacity, hot iron to remove the wiring and then unscrew them.

On most of the later breadboard sets, the underside identification tags can be removed by drawing out the tacks with a thin blade such as an Exacto knife. The very early sets used a glued tag which should be removed only if the restoration on the bottom side is very extensive. Most sets can be completely restored on top and touched up underneath with no damage to the glued paper tags. It is a good idea to protect the

paper with a plastic cover secured to the wood with masking tape. Do not let the tape touch the tag.

Refinishing the board can vary from light resanding of the original varnish and application of a wax overcoat to the removal of all the surface material and complete revarnishing. Generally, the less refinishing, the better. A completely new, high-gloss treatment looks strange to most viewers and can reduce the value of the set instead of increasing it. Assuming that complete removal of the varnish is not necessary, the restoring process is a series of gentle sandings to remove the surface defects caused by impacts to the surface and deeper sanding with grain refill to remove gouges and deep scratches.

Almost all of the old breadboard sets will show a discontinuous surface along the front and rear edges at the reinforcing end strips. The discontinuity results from differential contraction in the wood. Along the joint, the main board is cross-grained, and the end-strip is longitudinal. Most woods, including mahogony, expand and contract more across the grain than they do along the grain. Therefore, the board appears narrow or wide compared to the length of the end pieces. The author feels strongly that the end pieces should not be trimmed. The surfaces should not be made flush since the discontinuity is the natural result of the age of the set. The surfaces should be cleaned and smoothed but not matched.

A beautifully finished mahogany board is a major feature of the Atwater Kent Open Set. The dressing of these boards is not a difficult job. Even the complete refinishing is relatively easy. Disassembly of the instruments from the top of the Open Set board, and removal of the wiring from the bottom, are the parts of the job that most collectors are reluctant to try.

Board repair can be divided into four classes: minor touch up, complete surface treatment without removal of the original finish, repair of damage to the wood, and complete refinishing. These classes will be treated individually below.

Minor touchup of the board applies when its general condition is acceptable but a small area is found scratched or blemished with a foreign material. This is the most frustrating class of refinishing to a collector because the tendency is to do a better job in the small area than the finish which remains on the rest of the board. This leads to reworking the entire surface. Nevertheless, repair of the minor area is required before the comparison can be made.

The entire board should be cleaned even though only a minor area needs repair. There is usually a coat of grime which has been deposited from the air over the years, and it must be removed as the first step. This is the airborne organic material that is found on the inside of windows and on furniture. A mixture of alcohol, ammonia, and detergent loosens the grime and vigorous rubbing will clean the surface.

Then removal of local foreign matter should be tried using detergent and a light abrasive such as Ajax or Comet. This usually works well for water-soluble materials such as sugar, mud, chicken droppings, and other dirt. For grease, tar and oil-based material, toluene works quite well.

Light scratches and dents should be feathered with No. 240 and No. 400 abrasive. Using water with the sandpaper works very well. Even better for the surface is the use of a paint diluent such as turpentine or mineral-based thinner. Gloves should be worn when working with these materials to avoid excess drying of the skin. Care should be exercised to limit the sanding to the least amount necessary so as to avoid cutting all the way through the original finish.

Light gouges and deep scratches require sanding into the wood and filling with a wood putty or a wooden plug. The important factor here is to remove enough of the surrounding finish to permit smoothing of the entire local surface. Then by careful blending of stain, the colors can be matched and the blemish removed. The difficulty is that the different materials absorb stain at different rates. This will result in small areas of varying shades unless each material is specifically treated. A fine brush used with diluted non-grain-raising stain will permit different depths of color to be achieved in the sanded areas. To try the color, dampen the patch with the thinner, then apply the stain. Usually the final shade is lighter than the dried stain alone so the wetted patch will lead to a better match.

After matching the color on the patched area of plain wood, a light coat of thinned varnish applied to that portion will enable the refinishing of the remaining feathered surface. The process is to apply varnish in light coats sanding each to remove tiny defects such as dust particles, bubbles, and flakes of varnish until the desired thickness is obtained. The last step is to rub out the entire surface to break the shine and leave a lustre. No. 600 sandpaper with thinner will do this easily. It will leave a matte finish. Rubbing compound will produce the lustre that was characteristic of the original surface.

If the refinished patch is smoother than the remainder of the board, the collector has to face the problem: Should he refinish the rest of the board? A light sanding using No. 400 will often smooth the old varnish enough to permit a good comparison. Wet sandpaper using toluene (and gloves) aids in reducing the varnish surface. Great care is required to avoid cutting through the finish on the edges of the board and on the convex surface of the ogee curve.

For those who decide to add varnish but only to smooth the old surface, a finish sanding using No. 600 paper should be done after the No. 400. Then rubbing with compound will bring out the final lustre. A coat of hard wax can be applied to add surface protection. Butcher's or Trewax

is recommended. If the surface needs revarnishing, the No. 400 sanding is sufficient preparation. New varnish should be painted or sprayed, dried and resanded. Then the No. 600 should be used to obtain the final matte surface.

The third class mentioned above is that which requires new wood to repair the board or the re-gluing of the end pieces. Use of the old mahogany taken from a junk board (there are such things!) makes the best repair material. The bad section should be cut out using cuts along the grain or diagonal to it to avoid an unsightly discontinuity in the final appearance. The piece to be added should be cut similarly with especial care given to inside surfaces. These should be closely fitted so that the boundary is nearly indiscernable. If the new piece is oversize on external surfaces, there is no problem since these will be sanded smooth with the original surface.

For a hole in the main board, a plug can be made using a dowel. The dowel should be about 3/16 inches shorter than the depth of the hole. Two pieces of mahogany cut into disc-shaped covers and fitted precisely into the top and the bottom of the hole should be used to hide the plug. These discs must be aligned to match the grain direction and sanded smooth with the top and bottom of the board. The treatment of the finished surfaces is the same as for deep scratches.

Complete refinishing of the board differs very little from the foregoing treatments. The main factor is stripping off the old varnish and sanding down the resulting surface. Many good varnish removers are available. They should be checked for compatibility with the mahogany. Red Devil puts out a good remover and so does Sears. After the varnish is softened, it should be wiped off with thinner and the surface scraped lightly to remove the last sticky vestiges. No wood should be removed.

Next, scratches and gouges should be treated and the whole surface sanded (using fine sandpaper such as No. 400). Probably the color will have to be darkened using a compatible stain. Constantine's brown mahogany, non-grain-raising, is recommended. The surface should be checked for grain voids and filled with brown mahogany filler if needed. The original finish was a grain-free sheen. This finish is sometimes called "piano."

New varnish should be applied after the color has been applied and the filler has been smoothed. The varnish may be sprayed or painted as long as care is used to avoid runs. Spar and bar varnish may be used but these will be hard and therefore difficult to rub out. Urethane and acrylic varnishes are easier and provide a long-lasting protective finish that is moderately easy to smooth out. Several coats will be required with all defects removed between coats. No. 400 and No. 600 abrasive

will be very effective in treating each coat. The last coat should be rubbed with compound and then hard wax applied.

In the process of restoring the board surfaces, the wiring and screw holes will be partially filled with filler and varnish. These should be cleared by drilling before reassembly is started. If the spaghetti insulation was left in the board, use a small drill just about large enough to pass the wires through the center of the spaghetti.

The wiring should next be replaced, carefully threading the wires through their proper holes in the board. The staples should then be reinserted by starting them in their original holes with heavy pliers and tapping them home with a light hammer.

The instruments should be refastened to the top of the board using care to thread their wires through to the bottom. The underboard ends of the wires should be bent down and stapled lightly. Their ends should be soldered to the main runs by stroking the joint with a hot iron and adding solder during the stroke. A card placed under the joint will protect the board. After the joint has cooled and the card is removed, the staple should be driven in.

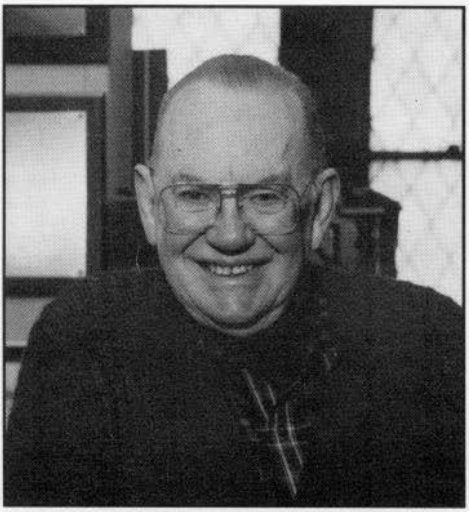
All that remains to be done is replacing the rubber feet, removing the protective covers from the tags and tightening the upper side binding posts. The refinished board with crafted wiring and clean instruments will be long treasured in any collection.

Appendix 2

This index lists the model numbers in numerical order. The page references are for the principal information paragraphs only. There may be references to the various models in other parts of the text and which are not listed here. Part numbers are not listed.

MODEL	PAGE	MODEL	PAGE	MODEL	PAGE
1	27	42	146	82Q	199
2	31	43	147	83	192
3	34	44	148	84	187
4	37	45	149	84Q	199
5	48	46	151	85	192
6	39	47	152	85Q	199
7	44	48	108, 153	86	194
8	52	49	153	87	195
9	53	50	156	87D	195
10	58	51	158	89	197
10A	69	52	158	90	201
10B	69	53	158	91	208
10C	73	55	161	91B	208
12	78	56	160	91C	208
12B	78	57	158	92	202
12C	78	58	158	93	206
Loudspeakers	81	60	166	94	202
19	91	60C	167	94F	202
21	95	61, 61C	171	96	203
20	84	66	169	99	204
20C	95	67	171	112	261
24	91	67C	171	126	303
30	102	70	173	135Z	278
30A	102	70D	176	136	303
32	108	72	173	137	263
33	112	74	173	145	272
35	116	75	173	155	245
Power Units	122	76	173	165	247
36	127	Q Chassis	176	165Q	248
37	130	H Chassis	182	168	291
38	137	80	189	184	298
40	140	81	198	185	247
41	144	82	190	185A	272

MODEL	PAGE
188	213
200	292
206, D	267
208	291
215Z	278
216	296
217	236
217D	240
225	296
228	212
236	297
237Q	301
246	235
248	291
255	296
257	263
260	215
266	235
273D	281
275	274
285Q	302
286	270
305Z	299
308	265
310	233
312	287
317	292
318	265
325	272
328	293
336	296
337	292
349	289
356	270
376, D	267
385Q	300
387	240
412	288
415Q	302
416	303
424	251
425	277
427	236
427D	240
427Q	240
435	296
446	303
447	264
448	231
456	297
465Q	277
467Q	301
469, F, D, Q	220
475	272
480	224
485Q	302
487	264
509	257
510	233
511	257
515Q	302
525	247
525Q	248
534	251
535	296
545	294
555	243
556	303
558, F, D, Q	219
559	255
565Z	299
567	211
577	264
608	288
612	225
625Q	300
627	218
627F	218
636	249
637	292
648	288
649	289
655Q	277
657Q	301
665	277
666	282
667	236
667D	240
676	297
708	241
710	285
711	260
717	292
725	296
735	272
747Q	301
755	294
756	249
756B	249
765	294
768Q	267
776	303
788	253
808, A	241
810	286
812	227
816	282
825	294
828	293
854	298
856	297
865	294
875	294
926	282
936	282
944	279
976	297
978Q	267



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Born in November, 1920, coincident with KDKA's first broadcast, Ralph attended high school in New Jersey, followed by Cooper Union College. When WWII intervened, he studied radar and after serving as a radar officer in China, he completed college at Northeastern University in Boston. After graduating in 1947, he joined General Electric and worked in various aspects of radio engineering. He developed an interest in the history of the radio art, and after a 1965 move to Philadelphia, he concentrated his efforts on the historical material of RCA and Atwater Kent.

He joined the AWA, and through association and with the encouragement of other collectors he rapidly built a collection of Atwater Kent radio artifacts. He obtained his master's degree in engineering science; his thesis was on the information-processing efficiency of the Morse telegraph code. Over the years he has been a steady contributor to the various programs and other activities of the AWA. His series of landmark articles on Atwater Kent radio receivers in the first three volumes of the AWA REVIEW, *unfortunately now out of print, are considered prime information sources for collectors.*

After retiring from GE in 1980, Ralph moved to Orient, NY on the northeastern end of Long Island, where he and Elinor and his excellent collection of Atwater Kent material reside in an historic house more than 300 years old.

Appendix 3: Supplement to the *AWA Review*, Volume 12, 1999

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THE ATWATER KENT RADIOS

By Ralph O. Williams

TUNED RADIO FREQUENCY RECEIVERS BATTERY AND HOUSE POWERED — MASTERLIST 1

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
1	22+	2	5	BATT	BOARD GRN	3925	OPEN	TAB	1	1	M		200		201			1
2	22+	3	5	BATT	BOARD GRN	3945	OPEN	TAB	1	1	M		200	201	201			2
3	22+	3	5	BATT	BOARD GRN	3955	OPEN	TAB	2	1	M		200	201	201			3
4	22+	3	5	BATT	BOARD GRN	3975	OPEN	TAB	5		M		200	201	201			4
5	23	5	5	BATT	BOARD GRN	4333	OPEN	TAB	3	1	H	201A(2)	200A	201A	201A			5
6	23	4	5	BATT	BOARD GRN	4052	OPEN	TAB	3	1	M	201	200	201	201			6
6	23	2	5	BATT	BOARD GRN	4120	OPEN	TAB	3	1	M	201	200					6
7	23	5	5	BATT	BOARD GRN	4066	OPEN	TAB	4	1	M	201(2)	200	201	201			7
7	23	3	5	BATT	BOARD GRN	4275	OPEN	TAB	4	1	M	201(2)	200					7
7	23	5	5	BATT	BOARD BLK	4205	OPEN	TAB	4	1	M	201A(2)	200A	201A	201A			7
8	23	5	5	BATT	BOARD GRN	4325	OPEN	TAB	3	2	M	201A(2)	200A	201A	201A			8
9	23	4	5	BATT	BOARD SMA	4445	OPEN	TAB	3	2	M	201	200	201	201			9
9	23	4	5	BATT	BOARD LGE	4445	OPEN	TAB	3	2	M	201A	200A	201A	201A			9
9C	24	4	5	BATT	BOARD BLK	4660	OPEN	TAB	1	2	H	201A	200A	201A	201A			9C
10	23	5	5	BATT	BOARD GRN	4340	OPEN	TAB	4	3	H	201(2)	200	201	201			1O
10A	24	5	5	BATT	BOARD BRN	4550	OPEN	TAB	4	3	H	201A(2)	200A	201A	201A		1-1	10A
10A	24	5	5	BATT	BOARD BLK	4560	OPEN	TAB	4	3	H	201A(2)	200A	201A	201A		1-1	10A
10B	24	5	5	BATT	BOARD BRN	4550	OPEN	TAB	5	3	H	201A(2)	200A	201A	201A	28P26	1-1	10B
10B	24	5	5	BATT	BOARD BLK	4560	OPEN	TAB	5	3	H	201A(2)	200A	201A	201A	28P26	1-1	10B
10C	24	5	5	BATT	BOARD BRN	4700	OPEN	TAB	3	3	E	201A(2)	200A	201A	201A	28P27	1-1	10C
12	23+	6	5	BATT	BOARD GRN	4375	OPEN	TAB	5	3	H	201(2)	200	201	201(2)			12
12B	24	6	5	BATT	BOARD BRN	4620	OPEN	TAB	6	3	H	201A(2)	200A	201A	201A(2)		1-2	12B
12C	24	6	5	BATT	BOARD BRN	4910	OPEN	TAB	4	3	E	201A(2)	200A	201A	201A(2)	28P28	1-2	12C
19	24	4	5	BATT	PANEL	4880	WOOD	TAB	2	2	E	201A	200A	201A	201A	2	1-2	19
20	24	5	5	BATT	PANEL	4640	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P29	1-2	20
20C	25	5	5	BATT	PANEL	7570	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P31	1-2	20C
20CL	25	5	5	BATT	PANEL	7960	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A		1-3	20CL

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
21	25	5	5	BATT	PANEL	7780	WOOD	TAB	2	·3	E	199(2)	199	199	199		1-3	21
22	24	6	5	BATT	PANEL	4930	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A(2)			22
24	25	5	5	BATT	PANEL	4920	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P27	1-2	24
30	25	6	5	BATT	PANEL	7950	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-4	30
30	25	6	5	BATT	PANEL	8000	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-4	30
30A	26	6	5	BATT	SHELF	8000	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-4	30A
32	26	7	5	BATT	PANEL	8270	WOOD	TAB	2	1	E	201A(4)	200A	201A	201A	28P36	1-4	32
33	27	6	5	BATT	SHELF	8930	WOOD	TAB	3	1	E	201A(3)	200A	201A	201A	28P38	1-5	33
33Pa	27	6	5	BATT	SHELF	8970	CNSL		3	1	E	201A(3)	200A	201A	201A		1-5	33Pa
35	26	6	5	BATT	SHELF	8100	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-4	35
35A	27	6	5	BATT	SHELF	8100	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-5	35A
36	27	7	1.5	110 60	SHELF	9390	WOOD	TAB	2	1	E	226(3)	227	226	171A	28P46	1-6	36
37	27	7	1.5	110 60	SHELF	9500	MET	TAB	1	1	E	226(3)	227	226	171A	28P52	1-7	37
37C	27+	7	1.5	110 60	SHELF	9700	CNSL		1	1	E	226(3)	227	226	171A		1-7	37C
37F	27	7	1.5	110 60	SHELF	9740	MET	TAB	1	1	E	226(3)	227	226	171A		1-7	37F
37FC	27+	7	1.5	110 60	SHELF	9830	CNSL		1	1	E	226(3)	227	226	171A		1-7	37FC
38	27	8	1.5	110 60	SHELF	9400	MET	TAB	1	1	E	226(4)	227	226	171A	28P56	1-7	38
40	27	7	1.5	110 60	SHELF	9800	MET	TAB	1	1	E	226(3)	227	226	171A	28P64	1-9	40
40F	27	7	1.5	110 25	SHELF	9960	MET	TAB	1	1	E	226(3)	227	226	171A		1-9	40F
41	27	8	5	110 60	SHELF	9910	MET	TAB	1	1	E	112A(4)	112A	171A	171A(2)	28P93	3-11	41
42	27	7	1.5	110 60	SHELF	9850	MET	TAB	1	1	E	226(3)	227	226	171A	28P64	1-9	42
42F	27	7	1.5	110 25	SHELF	9970	MET	TAB	1	1	E	226(3)	227	226	171A		1-9	42F
43	29	8	1.5	110 60	SHELF	9870	MET	TAB	1	1	F 2	226(3)	227	226	171A(2)	28P101	3-15	43
44	28	8	1.5	110 60	SHELF	9900	MET	TAB	1	1	E	226(4)	227	226	171A	28P66	1-19	44
44F	28	8	1.5	110 25	SHELF	9980	MET	TAB	1	1	E	226(4)	227	226	171A		1-19	44F
45	29	8	1.5	110 60	SHELF	9880	MET	TAB	1	1	E	226(4)	227	226	171A	28P66	1-19	45
46	29	6	1.5	110 60	SHELF	14100	MET	TAB	1	1	F 2	226(3)	227	226	171A(2)	28P101	1-15	46
47	29	9	1.5	110 60	SHELF	14500	MET	TAB	1	1	F 2	226(4)	227	226	171A(2)	28P66	1-15	47

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
48	29	6	5	BATT	SHELF	9640	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-5	48
49	29	6	5	BATT	SHELF	9860	WOOD	TAB	3	1	E	201A(3)	200A	201A	201A	28P38	1-5	49
50	27	7	5	BATT	SHIELD	8500	WOOD	TAB	2	3	E	201A(4)	200A	201A	201A	28P42	3-20	50
51	27	7	5	110 DC	SHELF	9890	MET	FL	1	1	13600	112A(4)	112A	171A	171A(2)	28P93	1-11	51
52	28	7	5	110 60	SHELF	9930	MET	FL	1	1	13600	226(3)	227	226	171A	28P64	1-9	52
53	29	8	5	110 60	SHELF	13100	MET	FL	1	1	14500	226(3)	227	226	171A(2)	28P64	3-15	53
55	29	7	2.5	110 60	BIG	14900	MET	TAB	2	WIN	14380	24A(2)	227	227	245(2)	29P4	3-21	55
55C	29	7	2.5	110 60	BIG	14800	CNSL		2	WIN	14100	24A(2)	227	227	245(2)		3-23	55C
55F	29+	7	2.5	110 60	BIG	15600	MET	TAB	2	WIN	14760	24A(2)	227	227	245(2)		3-24	55F
55FC	29+	7	2.5	110 60	BIG	15700	CNSL		2	WIN	14300	24A(2)	227	227	245(2)		3-24	55FC
56	29	7	1.5	110 60	SHELF	13900	MET	FL	1	1	13600	226(3)	227	226	171A	28P64	1-9	56
57	29	7	1.5	110 60	SHELF	14000	MET	FL	1	1	13600	226(3)	227	226	171A	28P65	1-9	57
60	29+	8	2.5	110 60	BIG	15000	MET	TAB	3	WIN	14770	24A(3)	227	227	245(2)		3-39	60
60C	29+	8	2.5	110 60	BIG	15100	CNSL		3	WIN	14410	24A(3)	227	227	245(2)	28P203	3-31	60C
60CL	29+	8	2.5	110 60	BIG	15100	CNSL		3	WIN	14380	24A(3)	227	227	245(2)		3-32	60CL
61	30	7	5	110 DC	BIG	15300	MET	TAB	3	WIN	14480	22(3)	112A	112A	171A(2)	30P141	3-36	61
61C	30	7	5	110 DC	BIG	15400	CNSL		3	WIN	14490	22(3)	112A	112A	171A(2)		3-40	61
66	30	9	2.5	110 60	BIG	15800	CNSL		3	WIN	14490	24A(3)	227	227	250(2)	30P143	3-40	66
67	30	7		BATT	BIG	15500	MET	TAB	3	WIN	14510	22(3)	112A	112A	171A(2)	30P145	3-43	67
67C	30	7		BATT	BIG	15200	CNSL		3	WIN	14520	22(3)	112A	112A	171A(2)		3-43	67C
70	31	8	2.5	110 60	BIG	16000	LO BOY		3	FAN	16400	24A(3)	27	27	45(2)	30P221	3-47	70
70F	31	8	2.5	110 25	BIG	16100	LO BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	70F
70Q	31	7		BATT	BIG	16800	LO BOY		3	WIN	16920	22(3)	112A	112A	171A(2)	30P243	3-55	70Q
70D	31	7	2.5	110 DC	BIG	16700	LO BOY		3	WIN	16900	22(3)	12	12	71A(2)	30P246	3-52	70D
74	31	8	2.5	110 60	BIG	16000	TABLE		3	WIN	16400	24A(3)	27	27	45(2)	30P221	3-47	74
74F	31	8	2.5	110 25	BIG	16100	TABLE		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	74F
75	31	8	2.5	110 60	BIG	16600	PHONO		3	WIN	16600	24A(3)	27	27	45(2)	30P231	3-60	75
76	31	8	2.5	110 60	BIG	16000	HI BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P221	3-47	76
76F	31	8	2.5	110 25	BIG	16100	HI BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	76F

EARLY BIG CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2A

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
72	31	9	2.5	110 60	BIG	16500	CNSL	LO HI	3	FAN	16400	35	35	27	36(2)	27		27	45(2)	12/31-264	3-63		130	72
83	31	6	2.5	110 60	BIG	21100	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47	11/31-281	3-67	80	130	83
83L	31	6	2.5	110 60	BIG	21100	CNSL	LO-BO	3	FAN	24600		35	27	35	24			47		3-67	80	130	83L
83F	31	6	2.5	110 25	BIG	22000	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47		3-67	80F	130	83F
85	31	6	2.5	110 60	BIG	17900	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47	11/31-284	3-89	82	130	85
85L	31	6	2.5	110 60	BIG	17900	CNSL	LO-BO	3	FAN	24600		35	27	35	24	24		47		3-89	82	130	85L
85F	31	6	2.5	110 25	BIG	18200	CNSL	LO-BO	3	FAN	18100		35	27	35	24	24		47	11/31-284	3-89	82F	130	85F
86	31	8	2.5	110 60	BIG	23000	CNSL	LOW-HI	3	FAN	24600	35	35	27	35	24	24		47	11/31-291	3-95		130	86
86F	31	8	2.5	110 25	BIG	24700	CNSL	LOW-HI	3	FAN	24600	35	35	27	35	24	24		47	11/31-291	3-97		130	86F
87	31	8	2.5	110 60	BIG	21200	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27		27	47(2)	11/31-292	3-99		130	87
87D	31	8	5	110 DC	BIG		CNSL	LOW-HI	3	FAN	25000	36	36	37	36	36		38	33(2)	12/31-324	3-103		130	87D
89	31	#	2.5	110 60	BIG	21300	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	11/31-293	3-105		130	89
89F	31	#	2.5	110 25	BIG	22400	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	11/31-293	3-105		130	89F
89P	31	#	2.5	110 60	BIG	20000	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	4/32-339	3-105		130	89P
96E	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-351	3-121		130	96E
96M	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47		3-123		130	96M
96L	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-353	3-125		130	96L
96F	32	8	2.5	110 60	BIG	26800	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-355	3-127		130	96F
99E	32	#	2.5	110 60	BIG	26200	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-357	3-129		130	99E
99L	32	#	2.5	110 25	BIG	26200	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-132		130	99L
99F	32	#	2.5	110 60	BIG	26900	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-133		130	99F
99P	32	#	2.5	110 60	BIG	27400	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-133		130	99P

LATER BIG CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2B

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
188	32	8	2.5	110 60	BIG	28400	CNSL		4	FAN	28700	58	58	56	58	55	57		47	7/32-377	3-135		130	188
188F	32	8	2.5	110 25	BIG	29300	CNSL		4	FAN	28700	58	58	56	58	55	57		47	7/32-377	3-135		130	188F
260	32	10	2.5	110 60	BIG	28900	CNSL		4	FAN TBM	28800	58	58	56	58(2)	55	57		47(2)	7/32-381	3-149		130	260
260F	32	10	2.5	110 25	BIG	29500	CNSL		4	FAN TBM	28800	58	58	56	58(2)	55	57		47(2)	7/32-381	3-151		130	260F
469	32+	9	2.5	110 60	BIG	29000	CNSL		4	FAN TBM	28800	58	58	56	58	55	57		47(2)	7/32-379	3-155	558	130	469
469F	32+	9	2.5	110 25	BIG	29400	CNSL		4	FAN TBM	28800	58	58	56	58	55	57		47(2)	7/32-379	3-157	558F	130	469F
480	32+	10	2.5	110 60	BIG	29600	CNSL		4	FAN	28800	58	58	56	58(2)	56	56		47(2)	1/33-409	3-159		472.5	480
480F	32+	10	2.5	110 25	BIG	29900	CNSL		4	FAN	28800	58	58	56	58(2)	56	56		47(2)	1/33-409	3-159		472.5	480F
612	32+	12	2.5	110 60	BIG	30000	CNSL		4	FAN TBM	30200-	58	58	56	58(2)	55	57		46(2)	1/33-403	3-171		130	612
812	32+	12	2.5	110 60	BIG	30500	CNSL		4	FAN TBM	30400-	58	58	56	58(2)	55	57		46(2)	11/25-2	3-175		130	812
448	33	8	2.5	110 60	BIG	32400	CNSL		4	FAN	28800	58	58	56	58	55	DET		47(2)	5/33-5	4-12		130	448
448F	33	8	2.5	110 25	BIG	32500	CNSL		4	FAN	28800	58	58	56	58	55	DET		47(2)	5/33-5	4-12		130	448F
510	33	10	2.5	110 60	BIG	36000	CNSL	MOD	4	FAN SH	36500	58	58	56	58	55	56	56	2A5(2)	5/34-15	4-8	310	130	510
310	33+	10	2.5	110 60	BIG	35900	CNSL	RNDED	4	FAN SH	36500	58	58	56	58	55	56	56	2A5(2)	5/34-15	4-8	510	130	310
112	34	12	2.5	110 60	BIG		CNSL		5	FAN SH	36700	58	58	58	58(2)	2B7	DET	56(3)	2A3(2)	10/34-2	6-1		472.5	112
711J	34	11	2.5	110 60	BIG	38600	CNSL	J,T			36700	58	58	56	58(2)	55	DET	56(2)	2A3(2)	5/34-27	4-21		472.5	711J,T
711R	34	11	2.5	110 60	BIG	36800	CNSL	R			36700	58	58	56	58(2)	55	DET	56(2)	2A3(2)		4-21		472.5	711R
487	34	7	2.5	110 60	BIG		CNSL				41800	58	2A7	MIX	58(2)	2A7	DET		2A5		6-43	577	472.5	487
788J	34	8	2.5	110 60			CNSL	J,T			39400	58	58	58	58(2)	2A6	DET		2A5	5/34-29	5-37		472.5	788J,T
788R	34	8	2.5	110 60			CNSL	R			39400	58	58	58	58(2)	2A6	DET		2A5		5-37		472.5	788R
808A	34	8	2.5	110 60	BIG	34600	CNSL				34500	58	58	58	58(2)	2A6	DET		2A5	5/34-33	4-21	808	472.5	808A
509	34+	9	2.5	110 60	BIG		CNSL	W	5	CLOCK	46600	58	2A7	MIX	58(2)	56	55		2A5(2)		6-45	511	472.5	509
511	34+	11	2.5	110 60	BIG		CNSL	W	5	CLOCK	36700	58	2A7	MIX	58(2)	2B7	DET	56(3)	2A3(2)	11/34-8	6-29	509	472.5	511
559	34+	9	2.5	110 60	BIG		CNSL		5	FAN	36500	58	58	58	58(2)	55	DET		2A5(2)	9/34-7	5-25		472.5	559
328	35	8	6.3	110 60			CNSL	L	5	FAN	54100	6K7	6A8	MIX	6K7(2	6H6	DET	6F5	6F6	2/36-2	6-18	828	472.5	328
312	34											6D6	6A7	MIX	6D6(2	76	DET	76(4)	2A3(2)		7-29		472.5	312
412	35	12	6.3	110 60	BIG		CNSL	G	5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412
412P	35	12	6.3	110 60	BIG		CNSL		5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412P
412X	35	12	6.3	230 60	BIG		CNSL		5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412X
710	36											6D6	6A7	MIX	6D6(2	6B7	DET	76(2)	45(2)		7-65		472.5	710
810	35	10	6.3	110 60	BIG		CNSL	G	5	FAN	53500	6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(3)	11/35-2	6-44		472.5	810
649P	36	9	6.3	110 60			CNSL	RP	5	FAN	50100	6K7	6A8	MIX	6K7(2	6H6	DET	6F5	6F6(2)	7/35-4	6-37	349	472.5	649P

LATER MEDIUM CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2C

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
469C	32+	9	6.3	110 DC	MED	31300	CNSL		3	FAN	31600	39	39	37	39	85	36		48(2)	1/33-397	3-163	558	130	469D
266	33	6	2.5	110 60	9X14	33300	CNSL		3	WIN	33400		57	56	58	55	DET		47	5/33-4	4-6	246	262.5	266
427	33	7	2.5	110 60	MED	35600	CNSL				33400	58	58	56	58	55	DET		2A5	5/34-9	4-4	217	264	427
427C	33	7	6.3	110 DC	MED	3700	CNSL				37600	78	78	37	78	75	75		43(2)	5/34-11	4-5	264	264	427D
808	33	8	2.5	110 60	MED	34600	CNSL		4	WIN	34500	58	58	58	58(2)	2A6	DET		2A5	9/23-3	4-17	708	472.5	808
286	34	6	2.5	110 60	MED		CNSL		4	AIR	41800	58	2A7	MIX	58	2A6	DET		2A5	7/35-3	6-15	356	472.5	286
318	34	8	2.5	110 60	9X14		CNSL		5	FAN SH	41600	58	2A7			55			2A5(2)	1/35-7	7-39	577	472.5	318
325	34	5	2.5	110 60	6X12		CNSL		4	AIR 3BD	41800		2A7	MIX	58	2A6	DET		2A5	9/34-3	5-7	145	264	325
376	34	6	2.5	110 60	MED		CNSL		4	AIR	43700	58	2A7			2A6			2A5	9/34-5	5-13	206	472.5	376
425	34	5	2.5	110 60	SML	39500	CNSL				33400		57	MIX	58	2A6	DET		2A5	5/34-21	4-24	665	264	425
525	34	5	2.5	110 60	MED	38400	CNSL				38500		57	MIX	58	2A6	DET		2A5	5/34-3	5-9	185	264	525
577	34	7	2.5	110 60	MED		CNSL		5	FAN	41800	58	2A7			2A6			2A5		7-43		472.5	577
665	34	5	2.5	110 60	MED	39600	CNSL	MOD			33400		57	MIX	58	2A6	DET		2A5	5/34-21	4-24	425	264	665
667	34	7	2.5	110 60	9X14	36100	CNSL	MOD	4	WIN	33400	58	58	56	58	55	DET		2A5	5/34-9	4-4	427	264	667
667C	34	7	6.3	110 DC	MED	37100	CNSL	MOD			37600	78	78	37	78	75	DET		43(2)	5/34-11	4-5	427D	264	667D
475	34+	5	2.5	110 60	MED		CNSL		4	AIR	41800		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	735	265	475
376C	34+	6	6.3	110 DC	MED		CNSL		4	AIR	43600	78	6A7	MIX	78	85	DET		43(2)		7-17	206D	472.5	376D
317	35	7	6.3	110 60	MED		CNSL	H	4	AIR		6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6	7/35-2	6-17	337	472.5	317
435	35+	5	6.3	110 60	6X11.5		CNSL	T	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6	7/35-1	6-21	225	450	435
649	35+	9	6.3	110 60	9X14		CNSL	L	5	FAN SH	50100	6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(2)	7/35-4	6-37	328	472.5	649
976	35+	6	6.3	110 60	8X12		CNSL	T	4	AIR 2BD			6A8	MIX	6K7	6H6	DET	6F5	6F6	7/35-3	6-45	856	264	976
535	36	5	6.3	110 60	MED		CNSL	M		AIR	41800		6A8	MIX	6K7	75	DET		6F6		7-37	725	450	535
676	36	6	6.3	110 60	MED		CNSL	B	4	AIR	41800		6A8	MIX	6K7	6H6	DET	6F5	6F6		6-45	456	264	676
717	36	7	6.3	110 60	MED		CNSL	H	4	AIR	41800	6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	637	472.5	717
765E	36	5	6.3	110 60	MED				4	AIR			6A7	MIX	6D6	75	DET		42		7-61		472.5	765E

EARLY MEDIUM CHASSIS SUPERHETERODYNE COMPACTS — MASTERLIST 2D

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
80	30	6	2.5	110 60	MED	20820	CPCT	ROUND	3	FAN	17300		35	27	35	24			47	11/31-282	3-67	83	130	80
80F	30	6	2.5	110 25	MED	21710	CPCT	ROUND	3	FAN	17300		35	27	35	24			47	11/31-292	3-67	83F	130	80F
82	30	6	2.5	110 60	MED	21090	CPCT	CATH	3	FAN	17300		35	27	35	24	24		47	11/31-284	3-75		130	82
82F	30	6	2.5	110 25	MED	21740	CPCT	CATH	3	FAN	17300		35	27	35	24	24		47		3-75		130	82F
82D	30	6	2.5	110 DC	MED	21750	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	11/31-285	3-71		130	82D
84	30	6	2.5	110 60	MED	18930	CPCT	CATH	3	FAN	17300		24	27	24	24			47	11/31-288	3-84		130	84
84L	30+	6	2.5	110 60	MED	20060	CPCT	CATH	3	FAN	17300		35	27	35	24			47	11/31-289	3-85		130	84L
84F	30	6	2.5	110 25	MED	19270	CPCT	CATH	3	FAN	17300		24	27	24	24			47	11/31-288	3-84		130	84F
84FL	30+	6	2.5	110 25	MED	20070	CPCT	CATH	3	FAN	17300		35	27	35	24			47	11/31-289	3-85		130	84FL
84D	30	6	2.5	110 DC	MED	19680	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	11/31-285	3-81		130	84D
84DL	30+	6	2.5	110 DC	MED	20080	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33		3-81		130	84DL
90	31	6	2.5	110 60	MED	25800	CPCT	ROUND	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-109		130	90
90F	31	6	2.5	110 25	MED	26500	CPCT	ROUND	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-109		130	90F
92	31	7	2.5	110 60	MED	25900	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-113		130	92
92F	31	7	2.5	110 25	MED	26600	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-345	3-115		130	92F
93	31	6	2.5	110 60	MED	27200	FLATTOP		3	FAN	NONE		24	27	27	NONE				4/32-347	3-117		130	93
94	31	6	2.5	110 60	MED	26000	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-349	3-119		130	94
94F	31	6	2.5	110 25	MED	26700	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-349	3-119		130	94F
228	32	8	2.5	110 60	MED	25900	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-139	92	130	228
228F	32	8	2.5	110 25	MED	26600	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-141	92F	130	228F
228C	32	6	6.3	110 DC	MED	21800	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	4/32-329	3-143	82D	130	228D
567	32	7	2.5	110 60	MED	25800	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-167	90	130	567
567F	32	7	2.5	110 25	MED	26500	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-167	90F	130	567F
558	32+	8	2.5	110 60	MED	29800	CPCT	CATH	3	FAN	17300	58	58	56	58	55	57		47	1/33-401	3-169		130	558
558F	32+	8	2.5	110 25	MED	30800	CPCT	CATH	3	FAN	17300	58	58	56	58	55	57		47	1/33-401			130	558F
558C	32+	8	6.3	110 DC	MED	31400	CPCT	CATH	3	FAN	31800	39	39	37	39	85	36		48(2)	1/33-397	3-163	469D	130	558D
627	32+	7	2.5	110 60	MED	29700	CPCT	CATH	3	FAN	17300	58	58	56	58	55	DET		47	1/33-405	3-173		130	627
627F	32+	7	2.5	110 25	MED	30700	CPCT	CATH	3	FAN	17300	58	58	56	58	55	DET		47	1/33-405	3-173		130	627F

LATER MEDIUM CHASSIS SUPERHETERODYNE COMPACTS — MASTERLIST 2E

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
155	33	5	6.3	110 ACDC	SML	32800	BOX	TREAS	2	WIN	24568		77	MIX	44	75	DET		43	3/33-2	3-179		262.5	155
165	33	5	2.5	110 60	6.5X10	34000	CPCT	ARCH	3	WIN	34100		57	MIX	58	2A6	DET		2A5	3/33-3	4-2	185	264	165
217	33	7	2.5	110 60	9X14	35500	CPCT	ARCH	4	WIN	36300	58	58	56	58	55	DET		2A5	5/34-9	4-4	427	264	217
217D	33	7	6.3	110 DC	MED	36900	CPCT	ARCH			37500	78	78	37	78	75	DET		43(2)	5/34-11	4-5	427D	264	217D
246	33	6	2.5	110 60	9X14	32000	CPCT	ARCH	4	WIN	32300		57	56	58	55	DET		47	1/33-3	3-147	266	262.5	246
555	33	5	2.5	110 60	5X10.5	32900	CPCT	CHEST	2	WIN	24408		57	MIX	58	55	DET		47	3/33-3	4-14		262.5	555
708	33	8	2.5	110 60	MED	34200	CPCT		4	WIN	34300	58	58	58	58(2)	2A6	DET		2A5	9/33-3	4-17	808	472.5	708
275	33+	5	6.3	110 ACDC	SML	36200	CPCT	FLT 8	4	WIN	26159		6A7	MIX	44	75	DET		43	5/34-13	4-7		264	275
145·	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD	42100		2A7	MIX	58	2A6	DET		2A5	9/34-3	5-7	325	264	145
145E	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD			2A7	MIX	58	2A6	DET		2A5		7-11		125	145E
145X	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD			2A7	MIX	58	2A6	DET		2A5		7-11		125	145X
185	34	5	2.5	110 60	6.5X10	38300	CPCT	ARCH	3	WIN	34100		57	MIX	58	2A6	DET		2A5	5/34-3	5-9	525	264	185
206	34	6	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900	58	2A7	MIX	58	2A6	DET		2A5	9/34-5	5-13	376	472.5	206
206D	34	6	5	110 DC								78	6A7	MIX	78	85	DET		43(2)		7-17	376D	472.5	206D
273D	34	3	2	110 DC	SMALL		CPCT	FLTTOP	4	WIN	NONE		1A6	MIX	34	34					7-26			273D
·356	34	6	2.5	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900	58	2A7	MIX	58	2A6	DET		2A5	7/35-3	6-15	286	472.5	356
825	34	5	6.3	110 ACDC	SML		CPCT		4	WIN	26159		6A7	MIX	44	75	DET		43	9/34-9	5-47		264	825
854	34	4	2.5	110 60	6.5X10		CPCT	FLT 15	3	WIN	34100		57			57			2A5	9/34-11	7-15		450	854
944	34	4	2.5	110 60	6.5X10		CPCT	ARCH	2	WIN	34100		57	MIX		57			2A5	9/34-11	5-49		450	944
185A	34+	5	2.5	110 60	SMALL	40000	CPCT	ARCH	2	WIN	34100		2A7	MIX	58	2A6	DET		2A5	5/34-7	5-11		264	185A
447	34+	7	2.5	110 60	9X14		CPCT		5	FAN SH	41700	58	2A7	MIX	(2)58	2A6	DET		2A5		7-39	318	472.5	447
735	34+	5	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	475	264	735
735	34+	5	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	735	264	475
225	35	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		6-21	435	450	225
337	35	7	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD		6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	317	472.5	337
545	35	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A7	MIX	6D6	75	DET		42	6/35-3	6-35		450	545
349	35+	9	6.3	110 60	9X14				5	FAN SH		6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(2)		6-37	649		349
137	36	7	2.5	110 60								58	58	56	58	55	DET		47		7-7			137
168	36	8	2.5	110 60								58	58	56	58	55	DET		47(2)		7-13		125	168
184	36	4	6.3	110 60	6.5X10		CPCT	FLT 14	3	WIN	52600		6C6	MIX		6C6			42	9/34-11	7-15		450	184
184X	36	4	6.3	110 60	6.5X10		CPCT	FLT 14	3	WIN	52600		6C6	MIX		6C6			42		7-15		450	184X
200	36	7	2.5	240 60	MED							6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	317	472.5	200
255	36	5	6.3	110 60									6A8	MIX	6K7	75	DET		6F6		7-25		450	255
456	36	6	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900		6A8	MIX	6K7	6H6	DET	6F5	6F6		6-45	676	264	456
637	36	7	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900	6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	717	472.5	637
725	36	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD	41900		6A8	MIX	6K7	75	DET		6F6		7-57	535	450	725
725P	36	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725P
725X	36	5	6.3	230 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725X
725PX	36	5	6.3	230 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725PX

AUTOMOBILE RADIOS, ALL — MASTERLIST 2F

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
81	31	7	6.3	BATT	AUTO	21048	3 UNITS			STEER'G	22600	36(3)	TRF			37	37		38(2)	11/31-383	3-69		TRF	81
81B	31	7	6.3	BATT	AUTO	21048	4UN SQ	BATT		STEER'G	22600	36(3)	TRF			37	37		38(2)	4/32-327	3-69		TRF	81B
81C	31	7	6.3	BATT	AUTO	21048	4UN FLT	BATT		STEER'G	22600	36(3)	TRF			37	37		38(2)	4/32-327	3-69		TRF	81C
91	32	9	6.3	BATT	AUTO	27700	3 UNITS			STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91
91B	32	9	6.3	BATT	AUTO	27700	4UN SQ	BATT		STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91B
91C	32	9	6.3	BATT	AUTO	27700	4UN FLT	BATT		STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91C
636	33	6	6.3	DYN SEP	AUTO	32100	4 UNITS		2		32600	39	36	MIX	39	85	DET		41(2)	4/33-2	3-181	756	263	636
756	33	6	6.3	CH DYN	AUTO	32200	3 UNITS				32700	39	36	MIX	39	85	DET		41(2)	4/33-4	3-183	636	263	756
756B	33	6	6.3	DYN SEP	AUTO	33600	4 UNITS				33700	39	36	MIX	39	85	DET		41(2)	4/33-4	3-183	636	263	756B
424	33	4	6.3	SYN VIB	AUTO	35000					25386		77	MIX	44	75	DET		41	7/33-4	4-11	534	264	424
534	33	4	6.3	SYN VIB	AUTO	35100		REMOTE			25534		77	MIX	44	75	DET		41	5/34-23	4-11	424	450	534
816	34	6	6.3	SYN VIB	AUTO	37400		REMOTE			26851	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	926	264	816
926	34	6	6.3	GENEMO	AUTO	39000		REMOTE			26851	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	816	264	926
936	34	6	6.3	GENEMO	AUTO	38800	3 UNITS	REMOTE			38900	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	816	264	936
666	34	6	6.3	VIBR	AUTO	39900		REMOTE			26851	6D6	6A7	MIX	6D6	85	DET		41	5/34-25	5-31		264	666
776	35	6	6.3	VIBR	AUTO	29296		CBLES ROUND			26851	6D6	6A7	MIX	6D6	85	DET		41	7/35-3	6-41		264	776
126	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-13	7-3	136	264	126
136	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32147	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-13	7-3	126	264	136
416	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7	6A8	MIX	6K7	6Q7	DET		6F6	5/36-13	7-3	126	264	416
446	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32147	6K7	6A8	MIX	6K7	6Q7	DET		6F6	5/36-13	7-3	126	264	446
556	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-12	7-49		264	556

LATER BATTERY POWERED AND 32 VOLT DISTRIBUTION RADIOS — MASTERLIST 2G

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
70Q	30	7	6	ABC	BIG	16800	CNSL	LO-BOY	3	FAN	15920	222(3)			TRF	112A		112A	71A(2)	12/30-241	3-55		TRF	70Q
76Q	30	7	6	ABC	BIG	16800	CNSL	HI-BOY	3	FAN	15920	222(3)			TRF	112A		112A	71A(2)	12/30-241	3-55		TRF	76Q
85Q	31	7	2	ABC	MED		CNSL		3	FAN	19900	32	32		32	30		30	33	11/31-290	3-93		130	85Q
469C	32+	9	2	ABC	MED	31100	CNSL		3	FAN	31500	34	34		34(2)	30	30	30	30(2)		3-165	558Q	130	469Q
427C	33	7	2	ABC	MED	35800	CNSL				36400	34	1A6		34	32		30	30(2)	5/34-17	4-9	387	264	427Q
525C	34	5	2	ABC		39100	CNSL				39200		1A6		34	32		30	19	5/34-5	4-23	165Q	264	525Q
655C	34	5	2	ABC			CNSL				43200		1A6		34	32		30	19	3/35-3	6-23	465Q	264	655Q
978C	34	8	2	AB			CNSL		4	AIR	43200		1C6		34(2)	30		32	30(3)		6-38	768Q	472.5	978Q
385C	35	5	2	ABC			CNSL		4	AIR	46800		1C6		34	32		30	19	735-5	6-19	625Q	264	385Q
285C	35	5	2	ABC	SMALL		CNSL	T	3	AIR	49900		1C6		34	30		32	33	6/35-4	6-13	415Q	450	285Q
467C	35+	7	2	6V VIB	MED		CNSL	H	4	AIR	50800		1C6		34(2)	1B5		30	19	8/35-1	6-12	237Q	472.5	467Q
747C	35+	7	2	AB	MED		CNSL	H	4	AIR	50800		1C6		34(2)	1B5		30	30(2)	3/36-11	7-55	657Q	472.5	747Q
485C	36	5	2	ABC	MED		CNSL	T	3	AIR	55600		1C6		1A4(2	1B5			33	3/36-7	7-55	515Q	450	485Q
82Q	31	7	2	ABC	MED		CPCT	CATH	3	FAN	18400	32	32	30	32	30		30	33	11/31-286	3-77		130	82Q
84Q	31	7	2	ABC	MED	19550	CPCT	CATH	3	FAN	18400	32	32	30	32	30		30	33	11/31-287	3-87		130	84Q
228C	32	7	2	ABC	MED	21900	CPCT		3	FAN	18400	32	32	30	32	32		30	33	4/32-331	3-145	82Q	130	228Q
558C	32+	8	2	ABC	MED	31200	CPCT		3	FAN	31700	34	34		34(2)	30	30	30	30(2)	133-399	3-165	469Q	130	558Q
387	33	7	2	ABC	9X14	35200	CPCT	ARCH	3	FAN	31700	34	1A6		34	32		30	30(2)	5/34-17	4-9	427Q	264	387
165C	34	5	2	ABC	6.5X10	38700	CPCT	ARCH	3	WIN	37170		1A6		34	32		30	19	5/34-5	4-23	525Q	264	165Q
465C	34	5	2	ABC	6X11.5		CPCT	ARCH	4	AIR	42900		1A6		34	32		30	19	3/35-3	6-23	655Q	264	465Q
768C	34	8	2	AB			CPCT		4		43100		1C6		34(2)	30		32	30(3)	3/35-5	6-38	978Q	472.5	768Q
625C	35	5	2	ABC	MED		CPCT		4	AIR	46700		1C6		34	32		30	19	7/35-5	6-19	385Q	264	625Q
415C	35	5	2	ABC	SMALL		CPCT	FLT	3	AIR	48500		1C6		34	30		32	33	6/35-4	6-13	285Q	450	415Q
237C	35+	7	2	6V VIB	MED		CPCT		4	AIR	50700		1C6		34(2)	1B5		30	19	8/35-2	6-12	467Q	472.5	237Q
657C	35+	7	2	AB	MED		CPCT		4	AIR	50700		1C6		34(2)	1B5		30	30(2)	3/36-11	7-55	747Q	472.5	657Q
515C	36	5	2	ABC	MED		CPCT	FLT	3	AIR	55500		1C6		1A4(2	1B5			33	3/36-7	7-41	485Q	450	515Q
135Z	34+	5	6.3	32 VIB	SMALL		CPCT		4		42700		6A7		78	75			43	8/35-3	6-7	215Z	264	135Z
215Z	34+	5	6.3	32 VIB	SMALL		CNSL		4		42800		6A7		78	75			43	8/35-3	6-7	135Z	264	215Z
305Z	35	5	6.3	32 VIB	8X12		CPCT	ARCH	4	AIR	42700		6A7		78	75			43	8/35-5	6-9	565Z	264	305Z
565Z	35	5	6.3	32 VIB	8X12		CNSL	T	4	AIR	42800		6A7		78	75			43	8/35-5	6-9	305Z	264	565Z