

ATWATER KENT EARLY RADIO DEVELOPMENT

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The Atwater Kent radio receivers that were built in the early nineteen twenties attract substantial attention and interest from present-day collectors, historians and students of industrial styling. Those earliest AK receivers, the Open Sets, dramatic as they appear when compared to modern radios, were nearly unique in their own time. Today, at least one Open Set, familiarly called a breadboard, is considered necessary for any radio collection that exemplifies the beginning of broadcasting. These radios, with their intriguing appearance, can tell a most interesting story about Atwater Kent and his time.

A single radio, when carefully examined and analyzed, can be the source of much information about the state of the technical art at the time of its manufacture. A series of radios, especially if they follow each other as members of a family, both in the flow of time and in the development of performance, can tell much more about the growth of the radio art and the evolution of manufacturing, distribution and use of radios in their period.

The main body of this paper is a series of descriptions and discussions of the radios in the Atwater Kent product line. It starts with the instruments which preceded the manufacture of complete radios. The Open Sets and the first of the cabinet receivers are then covered. Those readers whose main interest is in the technical characteristics of the radios themselves will find the descriptions starting in Section II. For students of the development of production in the field of radio manufacturing, Section I will discuss briefly the forces that Atwater Kent was eminently successful in harnessing to become one of the great names in radio history.

I — Before the Radios

Historians rarely have the luxury of studying extensive written records that might directly portray the specific interplay of the major forces in a technical society, especially in the fields of business and manufacturing. But the artifacts that result from the work of a major figure in these fields can often yield, upon analysis, enough of the story to provide the basis for detailed ancillary research, and at the same time make possible an interesting telling of the main technical story.

Surviving direct records of Arthur Atwater Kent, the man, are almost non-existent. Recollections by members of his family and former colleagues do exist and are being extended by oral-histories. Records of the manufacturing company for which Kent was so well known no longer exist, having been destroyed not long after the production operations were terminated decades

ago. But artifacts, the produced radios and the radio instruments made before radio production became the total business, have survived in quite extensive quantities and in excellent condition. They therefore offer an unparalleled opportunity for analysis and evaluation.

Any conclusions and judgments based largely on such an artifact analysis as is necessary to portray Atwater Kent will be flawed by the one-sidedness of the story. Such faults exist in this review. Analysis of the artifacts can be as accurate as the author's skill makes possible, but extensions to the societal forces lack sufficient verification, and must be recognized as being at best hypothetical or more accurately, postulatory.

A study of the major influences that have left clear traces in the actions of Arthur Atwater Kent illuminates the impact of forces so powerful as to almost completely reshape life in the mid-to-late twentieth century in America and Europe, even though Kent himself was not active in business after his plant was shut down in 1936.

The more important of these forces appear, at first glance, to be an odd lot: the development of very ductile steel; the extended understanding and utilization of assembly-line manufacturing; the application of modulated radio waves to the radiation of entertainment; and the increasing realization by the average early-twentieth-century citizen of the importance to him of knowledge about the rest of the world.

No single individual is ever the sole source or generator of a new way of life in a society, especially one as large as a nation. Study of the contributions of one person, however, in the development of the changes with which he is identified, facilitates understanding of that history. It leads to detailed characterization of contemporaries and of the social and technological forces that influenced the period of interest.

In a commercial field where the product is highly technological in nature, e.g., radio at the beginning of broadcasting, there was much cross-fertilization among the individual companies that competed in the general market. One reason for this was the engineering force which shared a common knowledge base and maintained close technical information exchange thru the Institute of Radio Engineers. Another reason appeared in the form of market limitation, i.e., the form of the end product and the way in which it was used. By this is meant, specifically, the transmission of cultural information via amplitude-modulated radio waves to receivers in the homes of non-technical families.

With a common technical base and common usage, the areas of individual contribution for any particular radio producer tended to be in three quite different facets of the business; product styling and identification, the means of distribution, and manufacturing sophistication and efficiency. Even these diverse aspects tended to become routine and prosaic because of such influences as customer taste and the cost of investing in product changes. Any emerging radio business had to work from the patent base controlled by the Radio Corporation, meet the usage and transmission requirements, create a strong customer demand, and in spite of these difficulties, make money. The

ways that Atwater Kent met all these demands to eventually become the record producer of radio sets reflect both the qualities of the man and the earlier experiences that shaped his career. A brief review of the early days serves well to understand the beginnings of Kent's unique line of instruments and receiving sets.

Atwater Kent started his business career very shortly before the turn of the twentieth century. He made electrical devices such as motors and fans and even a game called Amperia. In 1902 Kent moved to Philadelphia, where he produced electrical measuring instruments and a small telephone system called the Monoplex that was suitable for domestic interphone use. Although Atwater Kent manufactured electrical devices, his interests were broader than electricity. The mechanical quality of his products was very high and this could only have occurred if he were as strongly interested in the mechanical design as in the electrical function. Clearly apparent was his response to some of the technological forces operating at the turn of the century; the use of electricity to perform new services, mechanical embodiments using the best available technology, and perfection of product for both performance and reliability.

Kent's interest in things electrical and mechanical drew him to the automobile where he found and solved a problem worthy of his abilities, the generation of a precisely-timed energetic ignition spark. Early gasoline engines were generally operated at low speed, where the accuracy of the ignition spark was not a major limitation. In making improvements to engine performance, however, spark timing became a serious concern. Atwater Kent invented a means of precisely controlling both the occurrence and the duration of the spark with relation to valve and piston timing. The 1907 Spark Generator was the first unit to incorporate the very sophisticated spring-mass timing method which was later called the Unisparker, and for which Atwater Kent was awarded the John Scott Legacy Medal by the Franklin Institute in 1914. Ignition equipment produced by Kent's factory before the radio days is shown in Figure 1.

World War I brought a need to utilize the high quality and precise manufacturing capability of Kent's factory in Philadelphia for making military instruments. There he produced gun sighting and fuse setting equipment for the army. Figure 2 shows a pair of clinometers used to set the elevation angle of medium to large pieces of ordnance equipment. Also shown are three AK volt-ammeters and their leather cases.

Figure 3 pictures a very rare piece of precision AK military equipment, the gun-training theodolite. The device is a transit having the capability to measure or set both elevation and azimuth angles. Its optical path includes two prisms to confine the physical size of the telescope body to the dimensions of the precise leveling-screw plate that was the base of the instrument. To the left of the theodolite is its rather special case. When it was not being used for gun control, the instrument had to be cared for as a piece of precision optical equipment.

The work done by Atwater Kent on military instruments and on automobile ignition systems in the first two decades of the twentieth century brought ex-



Fig. 1. Ignition Components

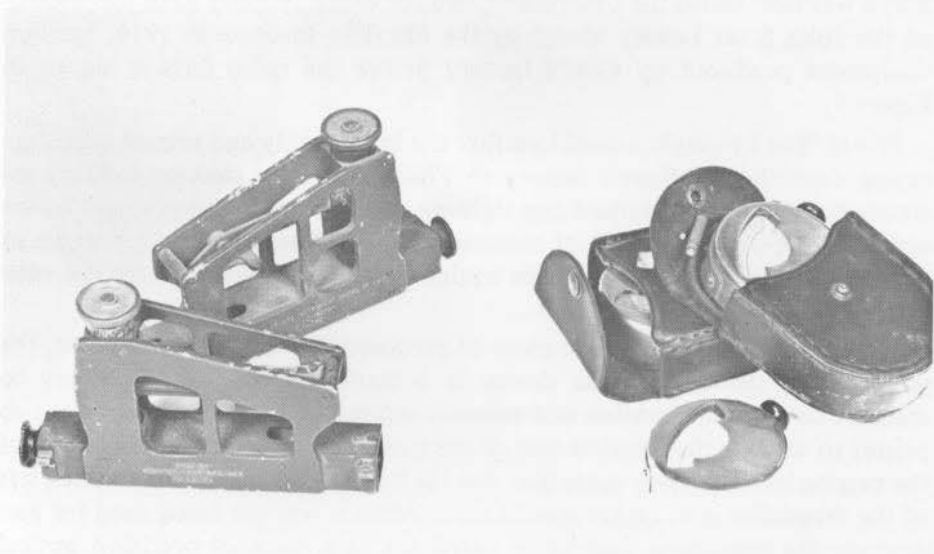


Fig. 2. Clinometers and Voltammeters



Fig. 3. Gun Training Theodolite

perience and familiarity in several highly specialized fields: high-voltage electrical components and systems; metal working, particularly in forming steel; insulation, especially in the casting of phenolics; and the manufacture of complex parts to tight standards. The marketing of ignition systems, and later, the expansion to full automotive electrical systems, brought Kent experience in another critical area, reaching his customer base. Through his dealer sales-and-service organization he became aware that the internal-combustion automobile was reshaping the attitudes and views of people who had hitherto been limited to their neighborhoods and small communities. The average man's horizon was expanding, but as yet, the forces that ultimately came together in the form of broadcasting had not been strongly felt.

II - Instruments and Radios

At the beginning of the 1920s radio experiments, performed by amateurs and commercial wireless companies, to examine the means and values of transmitting one-way, general-interest material pointed to a potentially stunning audience. David Sarnoff had partially succeeded in getting the Radio Corporation to develop a simple inexpensive receiver, but it fell to Dr. Frank Conrad of Westinghouse to put it all together; transmission, reception and public response. With the work of these men and the many more visionaries

like them, broadcasting was born. Radio manufacturing companies, such as Grebe, modified their products to participate in the growing radio market. Companies like Eiseman and Splitdorf that had ignition backgrounds considered the radio business a suitable expansion of their interests and later joined in the production of receivers.

Atwater Kent's factory was 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 to take the risks, and the vision to see the potential rewards. With no surviving records to document how AK entered the new market, the artifacts reveal that getting into the radio business was done on a progressive basis. First, instruments were designed and distributed. Careful analysis of instrument part numbers and contemporary advertisements indicates that the factory started production of radio instruments toward the end of 1921. With an active distribution system in place for the automotive-electrical product line, entering the radio business must have been relatively easy for the Atwater Kent Manufacturing Company.

Figure 4 shows the breadth of the product line. Two manufacturing techniques distinguish these instruments. One is the outstanding Bakelite casting capability and the other is the 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 4 demonstrates Atwater Kent's mastery of the art of shaping steel.

The inductive instruments and the amplifier-detector units were packed in cardboard boxes, that included data on the application and connection of the parts into complete radio receivers. Finished boards were also offered to enable simple mechanical assembly of a receiver using these parts. The boards were made of mahogany, edged with cross strips and finished in the brown color typical of their forerunners, the ignition system boxes.

The 3900 Series

Recognizing Mr. 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 first factory-built receivers bear this out. The first receiver, Part No. 3925, was introduced into production in November 1922, barely a year after the separate instruments came out. Figure 5 shows one of the two versions of this set. This configuration was never sold directly by Atwater Kent. The second 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 never licensed that patent from Armstrong. If a customer bought the set 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. Using this means to offer the advantages of the regenerator without paying royalties



Fig. 4. Radio Instruments

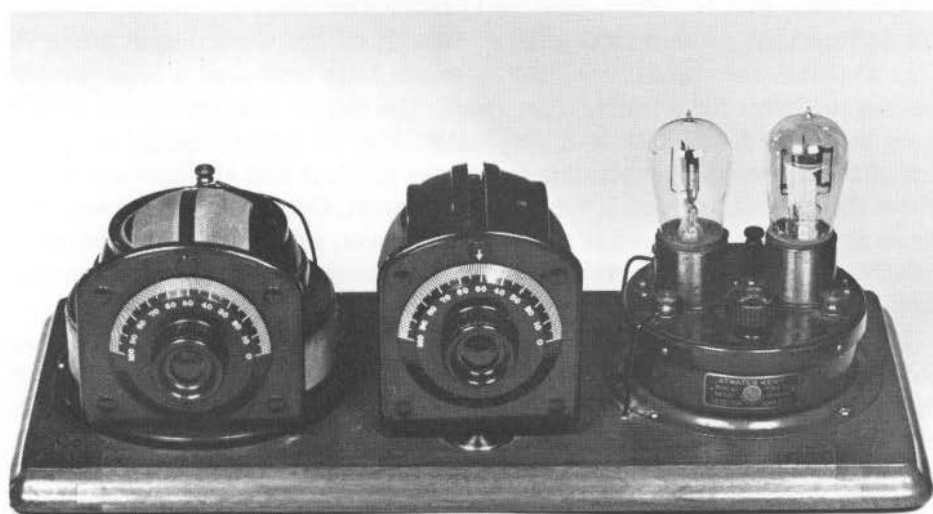


Fig. 5. No. 3925

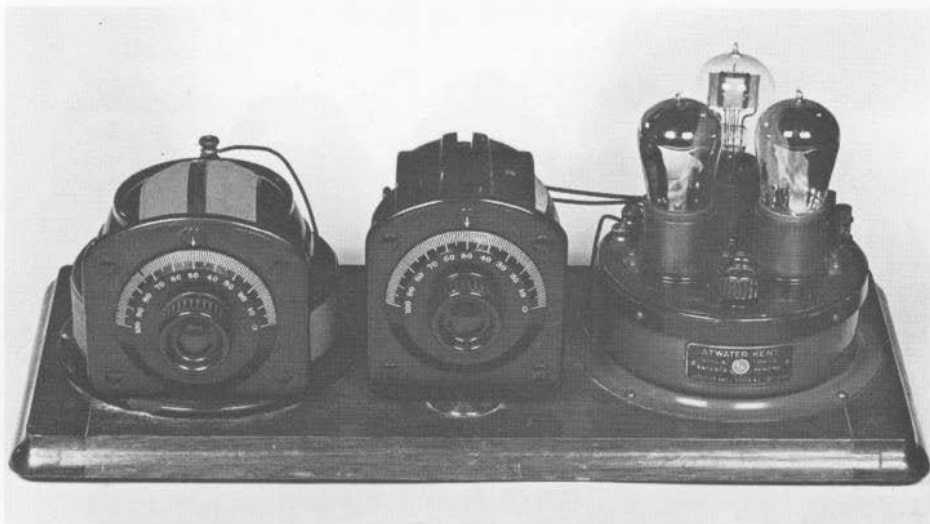


Fig. 6. No. 3945

to its inventor may possibly have been Kent's intention, but a more likely explanation is that Armstrong and Westinghouse limited the number of licenses. In any case, it is an interesting sidelight of the business side of early radio development.

This radio, Part No. 3925, used the Detector-One Stage TA unit for its electronic functions. With a local station typically of 100 watts output and a 70 foot antenna, the regenerator version would have produced a loud-speaker output sufficient for a small, quiet room. The simple detector version would have been heard well only with earphones. The TA unit contained an audio transformer, the detector bias condenser, the grid leak and all the connections. From the users standpoint it was very convenient. One disadvantage was that more audio amplification was not easy to connect, so the radio was limited in growth. 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 next radio receiver assembled by the factory was introduced into production one week after No. 3925. It too had a Part Number; 3945. Figure 6 illustrates the set. The difference between No. 3945 and the earlier one, No. 3925, was in the audio portion of the set where two amplifiers were found instead of only one. In both sets the audio amplifiers were incorporated in the deep-drawn metal cans. The amplifier tubes were socketed on the brown Bakelite top with the transformers buried in a protective tar fill inside the base. Since one amplifier tube and one detector were needed for the No. 3925, they were arranged along the cross-unit diameter resulting in an instrument about five inches wide on top. On the three-tube unit two transformers were buried in the tar. The two amplifier tubes were placed on a cross-unit line a little forward of the diameter. The detector was centered behind the amplifiers forming

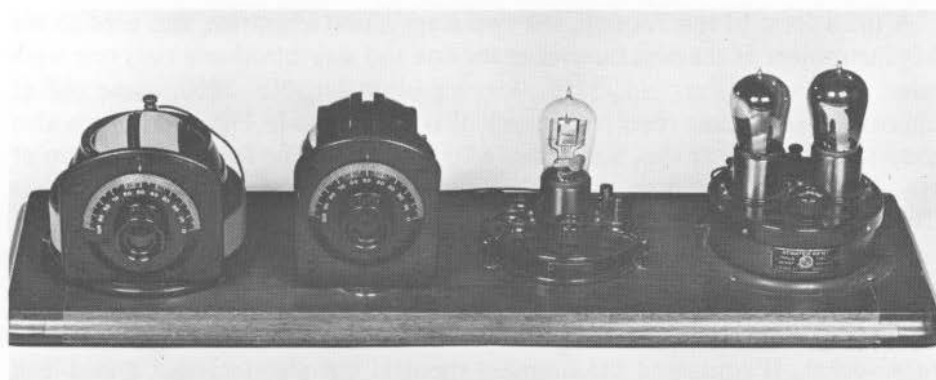


Fig. 7. No. 3960

a nearly equilateral triangle with them. This instrument was a little larger, almost six inches across the top. Again, the set was sold without the variometer to avoid infringing the regeneration patent. After purchase the owner could add the variometer, making the connections between that instrument and the P1 and P2 post behind the detector tube, as was done on the set illustrated.

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, at best, crude since the primary coil of the tuner had only three taps. It 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. When the variometer was added the selectivity was improved, since regeneration raised the grid impedance of the detector and because the increased sensitivity permitted the user to reduce the amount of coupling to the antenna. This receiver was capable of marginal loud speaker volume on local stations, using a long antenna, without the variometer. The regenerative version produced enough output on local stations to please the whole family.

In both of these sets, Atwater Kent provided an integrated unit, the TA detector-amplifier, that contained all the difficult connections. For several years subsequent to these sets, the same or very similar units, using exactly the same construction, were used on all AK 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 was no different 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.

A third form of the TA unit, the two-stage audio amplifier, was used as the key instrument of the next receiver in the line and was introduced only one week later. This set is Part No. 3955. A companion set, No. 3960, came out at almost the same time (two days later). It is illustrated in Figure 7, which also shows the variometer that was added after purchase. The full configuration of No. 3960 is, from left to right: Coupled Circuit Tuner, Variometer, Single Tube Detector, and 2 Stage TA-AF Amplifier. No. 3955 was of the basic form of the No. 3960 but was sold with only the Coupled Circuit Tuner and the Single Tube Detector mounted on the board.

The single-tube detector unit was similar in size and form to the standard tube socket. It contained the filament rheostat but also included a grid-leak resistor and grid condenser. Its plate circuit was brought out on two posts, with the lower-potential post connected to a plate by-pass condenser. The two-tube amplifier looked almost identical in size and layout to the detector-amplifier unit used on No. 3925, but differed in having no detector circuitry, and having two audio transformers buried in the tar of the base. The input posts on the top deck were connected to the primary of the first transformer. The output of the second tube was brought out on other posts for connection to a loud speaker or to several pairs of earphones.

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. 3955 which the customer could upgrade in two steps, each representing a resale for the dealer. First, perhaps, the customer bought the variometer and had the benefit of a one-tube regenerator. Then he could have returned and bought the two-tube amplifier to complete No. 3960. He would then have enjoyed a radio equivalent to the regenerative detector-two stage sets generally available from many contemporary manufacturers. When the No. 3960 was current, Atwater Kent dealers and other outlets still carried the full line of radio instruments made by the factory so that upgrading was easy. Examination of contemporary radio sets built at home by radio fans using AK 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 experiment as well as to purchase factory-built receivers.

In the 3900 series of receivers, Atwater Kent manufactured one more set, No. 3975. It was very similar to No. 3960, as may be seen by comparing Figure 8 to the earlier pictures. The difference in the full configurations of these two sets was in the tuning instrument. The Variocoupler was used on the No. 3975 instead of the Coupled Circuit Tuner that was used on the earlier sets. 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 their stray capacitances formed a tappable, tunable circuit resonant in the broadcast band, which at that time meant from a little more than 200 meters to a little more than 500 meters. The big advantage of the Variocoupler over the other instruments lay in the inductance taps.

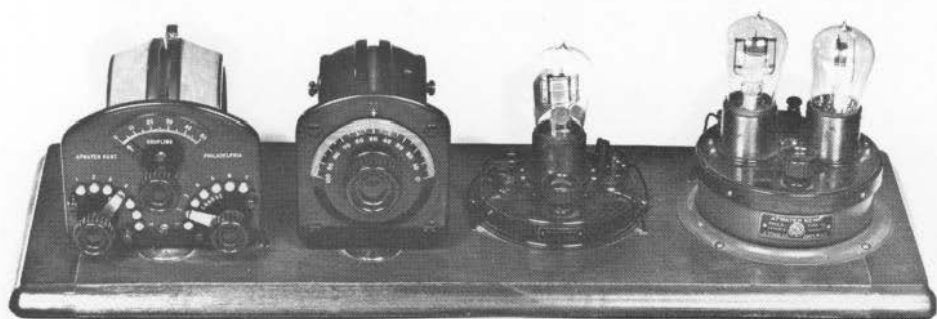


Fig. 8. No. 3975

The knob on the right, marked Coarse, permitted the user to select the number of turns he put in series with the antenna, six at a time. The left knob was for Fine selection at the rate of one turn per tap. By using these taps the operator changed the effective turns ratio between the antenna circuit and the grid circuit of the detector. This enabled maximizing the transfer of antenna energy to the detector (impedance matching). When this more effective matcher was used with the regeneration available by means of the 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 volume could be controlled by mismatching.

The No. 3900 series was the only family of AK receivers that could be made to regenerate conveniently. Atwater Kent may have recognized that regenerators were destined to be replaced by more docile circuits, ones that didn't require special experience to adjust properly, but so far no documentation indicating his attitude about regenerators has turned up. He may have been aware of the growing dissatisfaction in more densely populated neighborhoods with the tendency that regenerators had to operate in the lightly oscillating mode where they became annoying transmitters, tuned closely enough to the incoming signal frequency to produce program-destroying heterodynes in nearby receivers. It is easy to hypothesize that Kent, with his perceptiveness about what the customer would like best, and his sensitivity about his good name and the damage that could be done to it by the squealing, would try to avoid the problems of the regenerator. The next series of sets shows what he did, but doesn't tell why.

The 4000 Series

The last few months of 1922 and the first part of 1923 must have been busy times in the Atwater Kent Manufacturing Co. They were still producing electrical system parts for automobiles and had initiated the successful line of

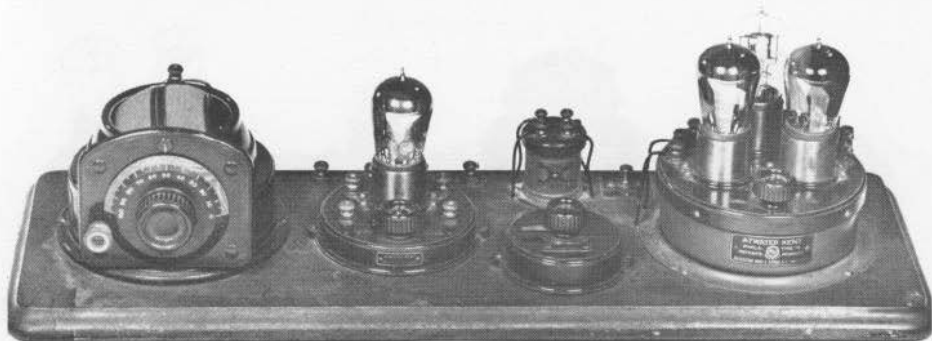


Fig. 9. No. 4052

radio instruments. The engineering people must have worked on both the regenerators and the new radio amplifier configuration at the same time. The production department not only carried along radio instrument manufacturing but 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, where the plant was located in Philadelphia.

Doubtless, in all this beehive of activity, Atwater Kent made his presence felt. From what is known of him through employees and his son, Mr. Kent took an active part in every phase of the business. He was active in the design, particularly in the mechanical side involving how the instruments appeared and how they were enclosed. He either closely supervised the layout of the assembly areas or did that job himself, since his admiration for Henry Ford's work is well known. Kent's insistence on quality was not relaxed in that period, either, since the artifacts show that appearance, function, fit and finish were maintained while new devices were brought on line.

The very end of 1922 saw production begin on five receivers in the 3900 series and then, in January 1923, the new line of radio sets was introduced. The first of these new open sets was No. 4052, shown in Figure 9. The new receiver was a four-tube set incorporating the detector-two stage audio amplifier unit that had been used earlier on No. 3945. To increase the amplification, a radio stage was included instead of offering a way to include regeneration. The radio amplifier was coupled to the detector by means of an iron-cored transformer shown to the immediate left of the three-tube unit.

Also added to the set was another new instrument, the potentiometer. It was wired across the filament circuit with its arm connected through the tuner to the grid of the radio amplifier. This instrument offered control of the radio stage amplification. The tuner was also new. Its purpose was to provide a resonator in the antenna-first grid circuit, where it made available very crude matching and some frequency selectivity. The tuner was designated Type 11. It

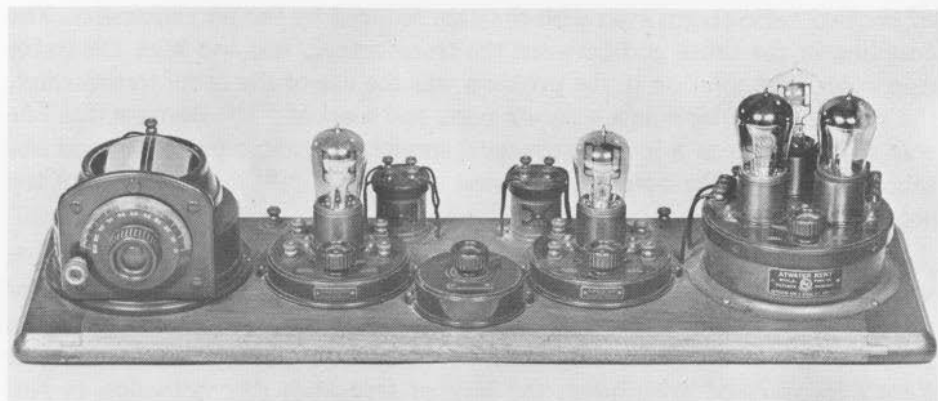


Fig. 10. No. 4066

was very similar, electrically, to the Variometer but looked different because the axis of the fixed coil had been turned from horizontal to vertical.

The interstage radio frequency transformer made possible a simple amplifier that was very similar to the standard audio amplifier used commonly in nearly all radios of the time. Because of the hundredfold increase in frequency, however, the unit was self-resonant. The transformer used in No. 4052 was marked "2" on its name plate. Another transformer marked "1" had been offered earlier as part of the original line of instruments. Apparently Kent and his engineers felt that the earlier 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. No. 4052 was not a high-performance receiver. With only the single fixed-tuned radio amplifier, its selectivity and its overall sensitivity were less than a well tuned three-tube regenerator, like the ones in the earlier series.

Radio engineers had found that the grid-leak detector followed by two transformer coupled audio amplifiers produced good output volume when the detector was operating with signals in the middle of its good-operating range. This was the basis of the AK three-tube unit and of the two-stage amplifier circuits offered by many other manufacturers, i.e., the RORK from Grebe and the 525 from Kennedy. Because more audio stages didn't solve the sensitivity problem, radio amplifiers (and regeneration) were investigated. One radio stage was not enough, even with a long antenna, for many radio listeners. Adding another stage was practical, although expensive, and that was the basis of No. 4066, the five-tube receiver shown in Figure 10.

Designing the AK open sets was not a difficult task. It consisted largely in putting together an attractive (to Mr. Kent) sample and making drawings of the new instruments and the assembly for the factory. The similarity of No. 4066 to its immediate predecessor makes this apparent. The electrical design of No. 4066 may have been a little more challenging, 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 to the problem was the use of the other transformer, the early one available as a separate part, and marked "1". Because that one was self-resonant at a lower frequency, moderately stable operation was obtained using it in the output of the first stage, with "2" in the output of the second.

A second effect was obtained although at the time of the set's introduction it was not of great benefit. The radio was broader in its response band because of the stagger tuning of the amplifiers. In early 1923 this resulted in more even amplification of the two mainly used wavelengths. Unfortunately for Atwater Kent's recovery of investment, the lack of frequency discrimination in No. 4066 resulted in almost instant obsolescence, when, in late 1923, the Radio Commission reassigned station frequencies across the entire broadcast band. The very limited selectivity produced by 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. Fixed-tuned radio amplifiers were a dead end, except for use in superheterodynes, and Atwater Kent could not have licensed that circuit even if he made that choice.

Three other open sets (not illustrated) were produced using fixed-tuned radio amplifiers. The first, No. 4120, was based on the No. 4052. It used a single tube detector instead of the three-tube unit. This was, therefore, a two tube set that would have been attractive to someone who already owned a two tube amplifier. The second set was based on the No. 4066, again substituting the single tube detector for the three-tube unit. It was identified as No. 4275. No. 4120 was introduced in March, 1923 and No. 4275 in June. The third set in this related group was No. 4205, introduced in late April, 1923. It was a No. 4066 that used A-suffix tubes. Prior to No. 4205, all Atwater Kent designs were based on the one-ampere filaments that were used in the 201 and 200 RCA type tubes. The new thoriated filament substantially increased emission, permitting the tube designers to reduce the filament temperature and consequently the filament current. The lower current tubes were given the A-suffix and rated at one-quarter ampere. Lower current required increased filament rheostat resistance and this led Atwater Kent engineers into modifying the several tube units, assigning new part numbers to the new versions. The change of the three-tube unit on No. 4066 therefore resulted in a change of the set number to No. 4205.

There was another set in this group based on No. 4066 but it looked so different that a detailed analysis was required to establish the similarities. The set was No. 4333, 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. Figure 11 illustrates the radio but does not make clear, except for the knob and tube count, why this is a No. 4066. Model 5 production was started in September 1923. Electrically, Model 5 was identical to No. 4066 with one exception; the radio amplifiers on Model 5 shared a common filament rheostat. Both sets



Fig. 11. Model 5, No. 4333

used Type 11 tuners in the antenna circuit and included two radio amplifiers with their iron-cored interstage transformers. The radio transformers in the Model 5 were suspended under the radio tube sockets using specially shaped bus wires.

The big difference between the two sets was in the use of a single drawn steel container to house all the parts that had been separately packaged in the No. 4066, as well as all the parts that were located in its three-tube unit. 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 exo-skeleton 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, 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 regeneration to make them oscillate when especially effective 201As are used in the radio

stages and the plate voltage is higher than about 45 volts. The set might well have turned into a bad sales problem if it had not been obsoleted by the need for selectivity. This resulted from the reassignment of frequencies by the Radio Commission at almost the same time as the Model 5 became available. Atwater Kent and his technical people must have been aware of the need for selectivity before the end of 1922, since another radio was being designed at the same time as the Model 5 and was introduced into production on the same day. It was Model 10.

Radiodyne and Model 10

Of the forces that came together so importantly for Atwater Kent, two have been discussed at some length in the descriptions of radios. They were the use of ductile steel to enclose the receiving instruments, and the manufacturing of radio sets by means of assembly line techniques. The latter force was more strongly felt as the number of radios produced per week increased beyond the craftsman stage, to the point where the operators performed only one or two related tasks on sets passing their work stations. The other two forces were not within Kent's direct control; rather they were the environment to which he responded. The first of these was the wave which carried the signal. Its characteristics influenced the circuits which he implemented, and determined the performance which he built into his receivers. The last force was the acceptance of the idea and of the importance of broadcasting by the general populace of the United States and Canada.

By the time that the 4000 series was obsoleted by the need to assign more than two wavelengths for general broadcasting (September, 1923) the count of licensed stations in those two countries had 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) but he recognized the market and what he had to do to substantially increase his share.

The selectivity requirement meant more tuned circuits. Overall receiver output was set by the listening public who wanted loudspeaker reception. Receiver input was determined by transmitter power and by the antennas used for transmission and reception. This required that the overall gain be at least ten thousand, and consequently made five stages necessary. Grid-leak detector limitations pointed directly to two radio amplifiers and two audio amplifiers. With the exception of the tuned circuits, this was the configuration of the unsatisfactory No. 4066. The next open set, No. 4340, added three tunable resonant circuits, fixed the problem, and started the run toward a million AK-made sets. That many were sold in the following four years. Atwater Kent more than recovered his investment in the electrical design that started with No. 4340, shown in Figure 12. The millionth set, a Model 35, had the same stage lineup and used the same tubes as that first three-dial receiver.

Two new instruments were developed for the No. 4340; a variable condenser and a radio transformer. The condenser 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

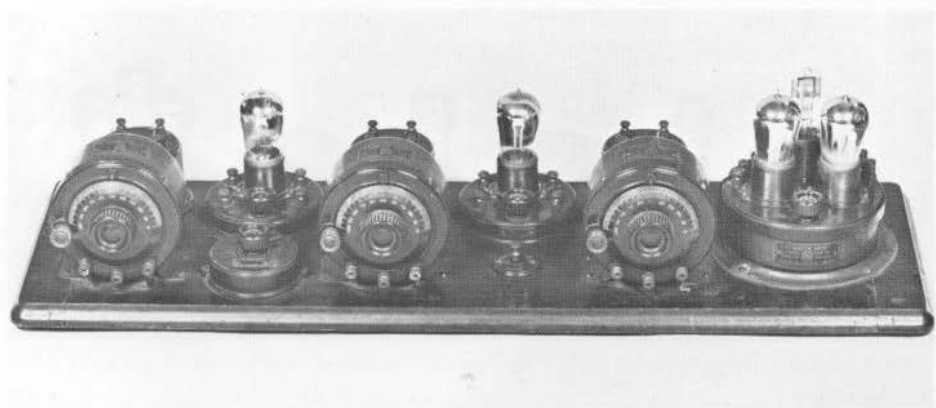


Fig. 12. Model 10, No. 4340

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 their circuits. 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 AK set had the real sales potential of strong visual appeal.

The name plates on the transformers tell an interesting story. They were marked along the lower edge (left side), with the word "Radiodyne". The introductory 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. The trouble was that the Western Coil Co. of Racine, Wisc. had previously established their right to the name. No information has 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 collections, but 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 sold very well. Therefore, the pressure to change the nameplates must have been intense, and how intense is indicated by two other No. 4340 sets that have come to light. They tell what was done in the interim until the photo-etcher had the new

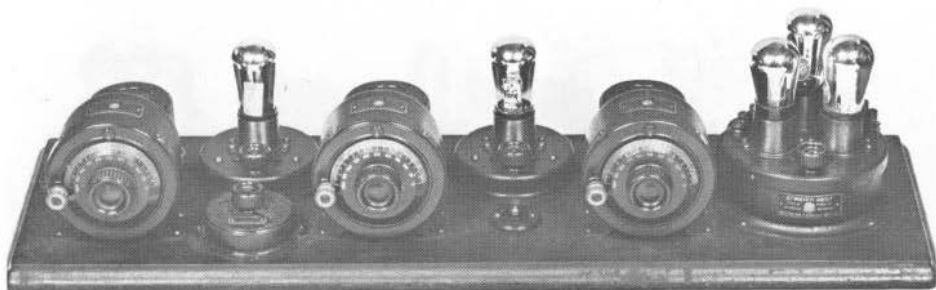


Fig. 13. Model 10, No. 4600

nameplates ready. The transformers on those two sets carried the same nameplates that 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 transformers that had been finished were altered, and the succeeding lots assembled with the interim and then the Model 10 nameplates. The production rate approximated 1000 sets per week.

"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 later into production 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 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 radio was made. Perhaps the reason for not assigning new numbers was that the production rate had all but swamped the still growing facilities. Most of the changes that took place in the four months or so of Model 10 assembly were cost reductions that only made minor alterations in the set's appearance, and were not deemed worth implementing on such a short production run.

Some of the changes that were made to the Model 10 were: The binding posts on the condensers were eliminated, holes were pierced in the rear of the condenser enclosure for the wires that were connected under the board, the binding posts on the radio transformers were removed so that the coil wires went directly to the underboard wiring, and the binding posts on the radio tube sockets were eliminated in similar fashion. These changes seem to have been made all together, 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 three black variations.

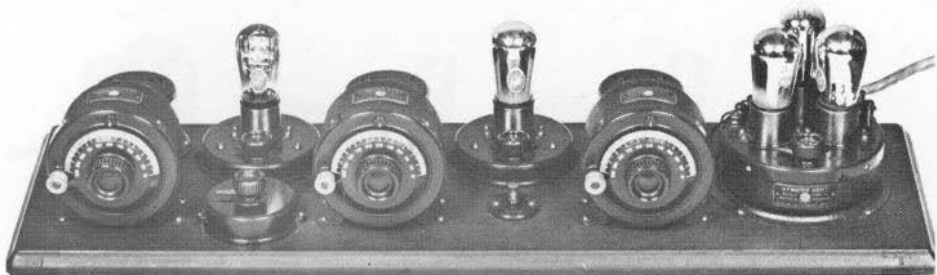


Fig. 14. Model 10A, No. 4550 or 4560

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 were substituted for the earlier ones with the binding post bosses, and the general arrangement of the underboard wiring 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 in a process, such as curing the phenolic. When that happened more machines had to be put on line if the rate was to continue to climb, and the new machines and lines would have required additional space. This growth may have been accommodated by changing the Stenton Avenue buildings, earlier used 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.

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. It is shown in Figure 13. 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.

Models 10A, 10B, and 10C

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

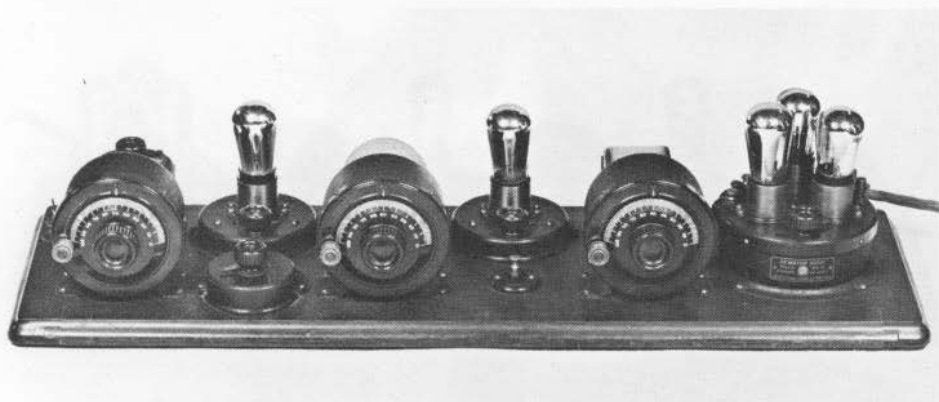


Fig. 15. Model 10B, No. 4550 or 4560

the year a new plant that was large enough for growth far beyond the open sets was built on Wissachickon Avenue in Germantown.

Improvement of the radios was accomplished by continuing the changes that started with the removal of the binding posts on Model 10. The next change was to add a power cord to the set, making it far more convenient to connect the batteries needed for its operation. It 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 colored brown, and No. 4560 for black. Receivers of either color were called Model 10A. A brown Model 10A is shown in Figure 14. On the illustrated set the binding post bosses may be seen on the radio transformers, but other sets came from the factory with the decorative rings on the coil forms. This suggests that the two facilities conjectured for Model 10 production continued to assemble open sets.

The practice of making minor appearance alterations without changing the identification numbers continued. Such variations included eliminating the nameplates from the condensers and the 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 are reckoned.

The tendency for the radio amplifier section of three-dial radios to regenerate was closely related to several factors; tube amplification, interelectrode capacity, and inter-coil geometry. Hazeltine developed and licensed a way of securing control of the latter two factors, but Atwater Kent preferred to go his own way. He rotated the transformers to orthogonal positions for the next set in the product line, Model 10B, shown in Figure 15. This change reduced the magnetic coupling between transformers but did nothing about the capacity coupling in the tubes. The set was still difficult to use when its greatest sensitivity was desired.

The popularity of the three-dialer came, not so much from its small signal performance, as its easy use by a family listening to the broad range of pro-

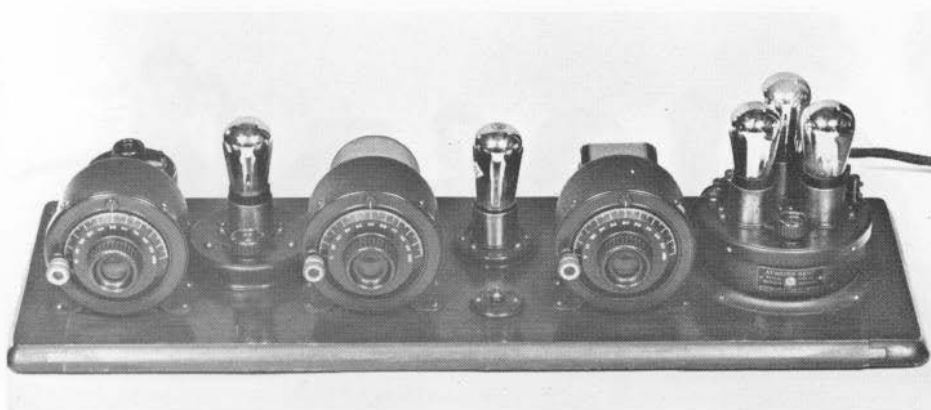


Fig. 16. Standard Model 10C, No. 4700

grams 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.

Another circuit improvement made the difference between earlier sets and the Model 10C, pictured in Figure 16. Damping resistors were added to the grid circuits of the radio amplifiers to make them less liable to regeneration. Neutralization might have been better but apparently Atwater Kent did not receive enough negative customer response to justify adding that feature. The damping circuits in Model 10C were carried forward for more than three years, even after Type 26 tubes replaced the 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 another benefit was available. Without the pot, the spacing between the first and second tuning condensers could be reduced. A change to the filament circuit to eliminate the rheostat in the second tube socket permitted reduced spacing between the second and third condensers. The radio in Figure 16 is the standard Model 10C, part No. 4700, which was two inches less in width than Models 10A and 10B.

Another version of Model 10C, illustrated in Figure 17, and also identified as No. 4700, was brought out, probably late in 1924. It was further reduced in width by about $3\frac{1}{2}$ inches, simply by locating the instruments closer to each other. The main identifying feature of that set, aside from the width, was the lack of end boards. It used strips that were rabbeted into the contoured ends of the main board instead of the full-thickness cross boards used on all other open sets. In late 1924 and early 1925, about forty thousand Model 10C receivers were produced and sold.

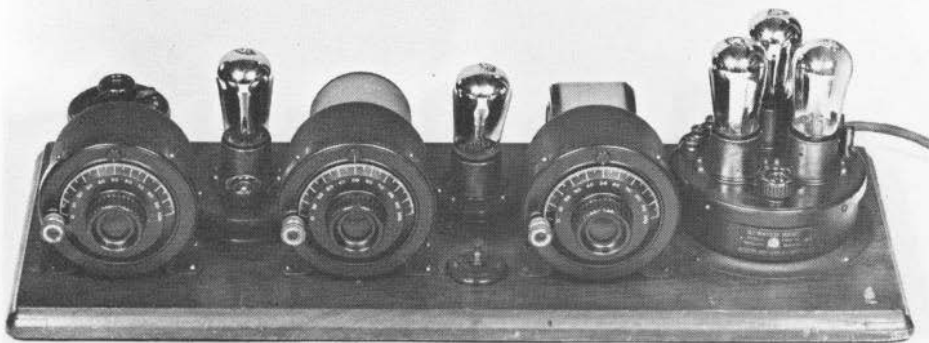


Fig. 17. Compact Model 10, No. 4700

Model 9 Receivers

Listeners who lived near higher-power local stations did not need two radio amplifiers on their receivers. For them, Atwater Kent produced four-tube receivers that started with No. 4052, but differed from that set by using a tunable radio amplifier in place of the fixed-tuned stage. The first of these tunable sets was introduced into production at the same time as the Model 10, September, 1923. It was identified as No. 4445, and then when model numbers came into use, called Model 9. Figure 18 shows the set.

The instrument in the middle was a Coupled Circuit Tuner, similar to the instrument that was offered separately for set constructors. It was a self-resonant tunable transformer made up of three coils; a rotor identical to that in the Type 11 tuner, a closely coupled spherical coil with which the rotor resonated, and an outer coil that acted as the primary of the transformer. The Model 9 receiver was a compromise between selectivity and price that must have been popular, because as the Model 10 sets developed, the Model 9s followed a similar course.

The illustrated Model 9 used binding posts for power and was painted green. Its immediate successor, not illustrated, used a cable for power and was painted brown. Then at the time of the Model 10C a different configuration of the four-tube radio was introduced. It was identified as Model 9C, No. 4660, and is shown in Figure 19. The Model 9C was, from both circuit and mechanical standpoints, almost exactly a Model 10C with the middle stage removed. It was painted brown and used a cable for its power connections. In the same way that Model 10C was the predecessor of Model 20, the Model 9C preceded the Model 19.

Model 12 Receivers

Among Atwater Kent open sets, the Model 10 series seems to provide the basis for portraying the development of the entire product line. Model 9 could

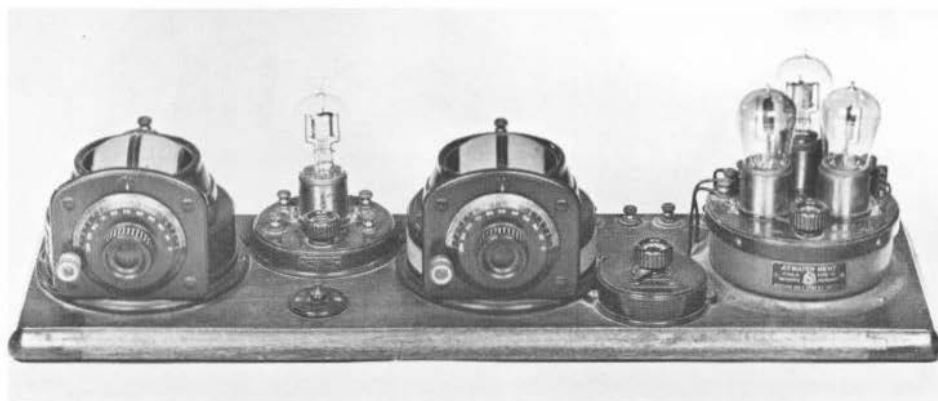


Fig. 18. Model 9, No. 4445

very easily be considered as a simplification of the technology of Model 10. Model 12 could be treated as an extension. The difference between any Model 12 and its Model 10 counterpart was in the number of audio amplifiers and how they were packaged. The development work for this variation was done at the time the individual instruments were the product line, before the production of radio sets began. Only application and assembly work was required to manufacture the Model 12. The last of the six-tube open sets, Model 12C, No. 4910, is shown in Figure 20. Clearly the radio section was that of the Model 10C, even to the placement of the coils and the switch. The difference is in the use of the Detector-One Stage Amplifier and the Two Stage Amplifier instead of the three-tube unit on the Model 10C. In recognizing this set, the key points were the small tube socket for the second radio amplifier and the stage-disable switch on the second two-tube unit.

Corresponding to the Model 10B receiver, Atwater Kent produced a six-tube set, usually referred to as a Model 12B, No. 4620, although there is no clear documentary basis for the suffix letter. The set, not illustrated, used the radio section from the Model 10B and the two-tube units that functioned like those on the Model 12C, except for the stage-switch which hadn't been included.

From performance measurements made on the Model 12 series, the inclusion of the 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. For the listener who was especially interested in distance listening, however, the Model 12 was the best choice.

A third Model 12 style, a six-tube set, was produced when the five-tube Radiodyne was introduced (and withdrawn). Like the later ones, this six-tube receiver used the same radio section as the corresponding Model 10, in this case the Radiodyne, even to the nameplates on the transformers. No mention of this radio as a Model 12 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. The

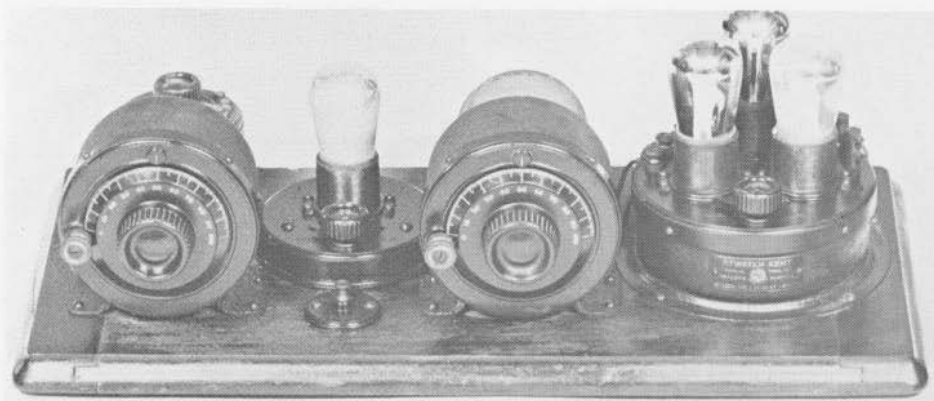


Fig. 19. Model 9C, No. 4660

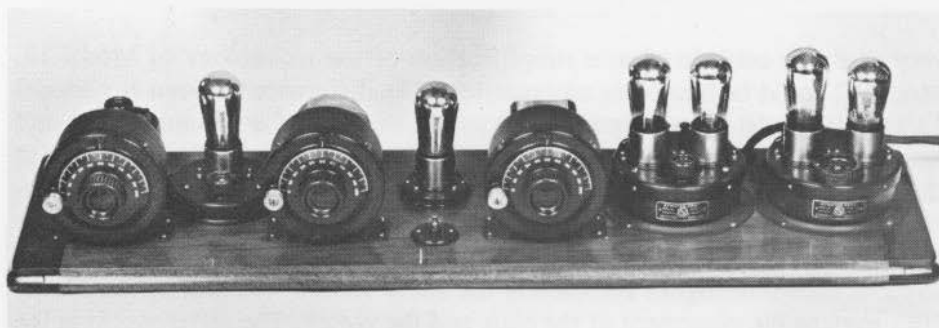


Fig. 20. Model 12, No. 4910

two-tube units on that set were identical to those used in the 3900 series of receivers even to the color, green. No example of a model corresponding to the first Model 10 (changed nameplates) or its variations has turned up.

Conclusion

In producing and selling more than 120,000 open sets, Atwater Kent demonstrated how an entrepreneur can combine the offerings of a new technology, his own capability and the needs of a society to initiate changes that endure far beyond the times in which they were made. In many ways he was an explorer, and like many other pioneers, he was driven by internal forces that left neither time nor opportunity to see the effects that his work would leave. This is the task of the collector/historian.

Production of the open sets led to an efficient factory, and broadcasting led to a new way of life. Atwater Kent continued in the radio business, producing ever more radio sets and becoming an active user of broadcasting's power and influence. The story of the wooden box receivers and of the metal box radios that followed iterates and strongly emphasizes the contributions that Arthur

Atwater Kent made to a new way of life. His story can be told many times with different faces, different needs and different artifacts, but his example will be long remembered.

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