

ATWATER KENT RADIO DEVELOPMENT — PART III

THE A.C. POWERED RECEIVERS

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INTRODUCTION

Continued growth of the AK 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. (see: ATWATER KENT EARLY RADIO DEVELOPMENT — THE MAHOGANY AND METAL BOXES, *THE AWA REVIEW*, Volume 2). In only five years, radio receivers had progressed from single-tube detectors through regenerators to one-dial TRFs. 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 A.C. 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 AK products during that time gives a good picture of the problems that all had to solve, and how AK went about solving them. Part 3 of this series picks up the story at the time when the house-powered, alternating-current radio set became a reality.

FROM MAHOGANY TO STEEL — THE MODEL 36

For AK, the electric-radio concept came together in the Model 36, Fig. 42. 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 the 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 201A tube was not satisfactory with A.C. heating its filament. With the exception of its 1½ volt filament, the 226 had the same operating characteristics as the 201A, and consequently required no changes in circuit parameters. For detector operation, however, the 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

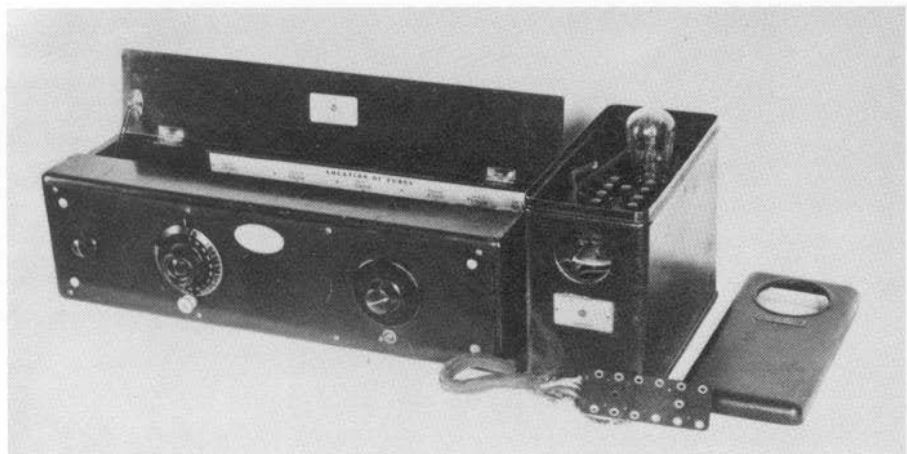


Fig. 42. Model 36*

Photo: R. Williams

made an excellent grid-leak detector. Because the 227 added a cathode element, it was given a five-pin base. Only minor changes were made to the mahogany box to accommodate the A.C. filament tubes and to the cable to bring filament power for them from the power supply; e.g., AK recast the detector shelf to accommodate the extra pin of the detector tube.

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 UX171 (later 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 201A but it used more current, operated at a higher plate voltage and had to be biased.

The Model R power unit that AK 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 high enough voltage to provide for both the plate and bias requirements of the 171A. The needed 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 type 280, an upgraded 213, which met the requirements admirably. Model 36 and all but one of the subsequent AK receivers included the 280 rectifier or its octal version (5Z4).

* Note: The first 41 pictures of the Atwater Kent radio sets are in *THE AWA REVIEW*, Vol. I and Vol. II. The story continues here, with the illustrations starting at Fig. 42.

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 AK to get into the market before the version he wanted to produce, Model 37, was ready. In looking back, the Model 36 is one of the more interesting sets in the AK 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.

THE MODEL 37 — STEEL STYLED FOR PROGRESS

In reviewing the few records that are still to be found about AK it becomes clear that 1927 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, Fig. 43, was the first one to incorporate a power supply, together with the radio and audio circuits, in a single enclosure. The appearance that the modern Model 37 made in a living room of the late twenties was quite an improvement over the *passé* look of the earlier mahogany boxes. The metal case left an impression of the benefits of technology, where the older wooden boxes were only variations of common household containers. AK was very much in tune with the attitude of the times in using the steel enclosures.

Because the steel industry, together with the automobile industry, had developed ductile steel and suitable machine tools for shaping large body panels, an ordinary individual would have been familiar with the changes in car fashions and welcomed the results. The new automobile styles made



Fig. 43. Model 37

Photo: R. Williams

everyone aware that steel shaping was a wonderful improvement. Closer to the 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.

AK must have had a very clear picture of the acceptance of the metal radio box. The sales of Model 35 were abundant evidence that style was selling radios since that set was really a repackaged Model 30. Although AK 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 so as to be able to fabricate Model 37 cabinets in quantity, and that was one of Mr. Kent's specialties. The AK story 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 one in between, Model 37.

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 as a channel about thirty inches long. Then it was restamped 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. Properly shaping and sizing the cover took the highly skilled metal-drawing work that characterized the AK factory. 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 was sloppy. 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 covers made for one run of sets do not necessarily fit others. Present-day collectors know how difficult prying off a good looking cover can get.

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. 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 same way that AK made only minor changes to go from Model 33 to the signal circuits of Model 36, his engineers started with the Model 35 chassis,

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 226, 227, and 171A. In order to integrate the Model 36 power supply (Model Y) in the single cabinet of Model 37, the power supply had to be mechanically redesigned. Electrically, no changes were necessary but the arrangement, 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 unit with 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 in the filter condensers. During the active years for the metal-box sets, when customers needed dealer service, repair was made by replacing the entire power unit. 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 80 rectifier tube that could be heavily overloaded. Sometimes in a restoration, the 80 is found to be defunct but that has saved the transformer. Nevertheless, replacing the condensers is an adventure in working with potting tar.

Two versions of Model 37 were produced. The difference between them was in the tuning condensers. The earlier sets used 17-plate tuning condensers, the later ones used 13 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.

PARALLEL PRODUCT LINES AND THE MODEL 38

AK carried parallel lines of receivers through all the model years of his production. Parallel product lines were the result of customer preferences. The first directly-related example of parallels was Model 10 with Model 12 (Radiodynes). In the mahogany boxes, Model 30 paralleled Model 32 (or 33). There even appears to have been a six-tube version of Model 20, identified as Model 22. The parallels continued into the metal box production; Model 37 was accompanied by Model 38. Some families were pleased with the standard, highly effective, seven-tube radio that was AK's main offering. Others wanted the more expensive, slightly more sensitive and probably more impressive eight-tube, top-of-the-line receiver.

Model 38 used the radio and audio circuits from Model 33, added the power supply developed for Model 37, and utilized a cabinet that was about four inches wider than Model 37 to accommodate the extra radio amplifier. 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 brown dial, the gold vernier and the ship medallion.

Models 37 and 38 were excellent radios in their time. They were sensitive, selective, and provided good volume on all but the weakest signals. They could be overloaded on very strong signals but with a good ground the volume control was effective. Two irritating features (common to many tuned-radio-frequency amplifier receivers of that time) were difficult tuning at the high-frequency end of the dial, and excessive signal variation as the set was tuned over the band. Because of the many pleasures that Models 37 and 38 brought into the home, those flaws were not noticed. Although exact figures are unavailable, the total production of Models 37 and 38 appears to have been upwards of half a million.

THE STEEL CABINET RADIOS, MODELS 40, 42 & 44

Based upon the immediate success that AK enjoyed with Model 37, it must have been easy to decide what to do for 1928. Manufacturing had only to keep the production lines operating at full speed. Engineering was to make only minor changes to the design, minimize costly impacts on production, and change the appearance of the set enough to assure clear and separate identification in the marketplace.

For 1928, the seven-tube (standard) radio became Model 40. The eight-tube (top-of-the-line) receiver that replaced Model 38 was Model 44, Fig. 44. From



Fig. 44.
Model 44 Desk

Photo: R. Williams

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.

The changes in appearance were a new cover that was slightly convex in cross-section, and a new decorative medallion. The new decoration was hexagonal 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 could see a new power supply. The enclosure had been changed from a folded box to a drawn enclosure and cover, not so much to provide customer appeal, as 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 AK 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.

THE LINE REGULATOR MODELS 42 AND 44

In the twenties, the line-voltage regulation on the fringes of some alternating-current distribution systems was sometimes very poor. If the nominal 110-volt line dropped to 95 volts, radios were subject to failure because the filaments cooled too much for satisfactory emission. To cope with the excessive voltage changes, AK brought out Model 42, which incorporated a series regulator in the primary of the power transformer. The nominal voltage required by the transformer was about 70 volts. The regulating resistance took up the difference, whether it was 40 volts, based on the normal line voltage, or a lower value, e.g., 20 based on a line voltage of 90 volts. The same changes were made in the eight-tube set that was derived from Model 38 to make Model 44.

Not all alternating-current generating systems operated at 60 Hz. The stations at Niagara Falls produced prodigious amounts of power but it was at 25 Hz. AK's designs were adequate for 25-Hz service except for the power transformer. AK altered Models 40, 42, and 44 to meet the needs of the 25-Hz market by substituting transformers having higher primary inductance and by adding filtering. These sets were identified with the suffix letter F.

THE DIRECT CURRENT RADIO — MODEL 41

Edison and the proponents of alternating-current distribution systems 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 A.C. radios that were the thrust of the late twenties. AK saw the D.C. 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 again a simple matter to modify the filament circuits and add a direct-current filter for the main power. Type 112A tubes were substitutes for the 226 amplifiers and the 227 detector.

The normal plate voltage used for operation of the triode amplifiers in Model 40 and similar alternating-current sets was in the range of 140 to 155 volts. The direct-current set, Model 41, did not have the benefit of voltage step-up in a power transformer, so its maximum plate voltage was little more than 80 volts. Because direct-current mains were noisy, additional filtering was necessary for the low-level amplifiers and, therefore, their plate voltages were only about 65 volts. Reduced plate voltage resulted in reduced stage gain. To make up for the loss in overall gain, the output stage was made push-pull. This nearly doubled the overall receiver gain, and almost made up for the gain reduction caused by the low plate voltage. The push-pull output tubes, 171As, were transformer coupled from the first audio amplifier and shunt-fed in their plate circuits. The loud speaker was connected directly from plate to plate.

Since extensive production changes were undesirable, the extra output tube was fastened to a tube shelf attached to the power supply enclosure. This was similar to the way the rectifier tube socket in the alternating-current sets was fastened, but it was attached to the other end of the power supply enclosure. Adherence to AK's precept of limited redesign was exemplified by the fact that the amplifier socket was the same phenolic part as the rectifier socket in Model 40. The bracket and the screws were also identical in the two sets. Model 41 was the last of the three-tuning-condenser cabinet sets to use the Model E magnetic loudspeaker.

Model 41 performed well, partly because it was generally used 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 ELECTRODYNAMIC SPEAKER — MODEL F

Improvements in loud speakers came slowly during the twenties. Not until 1928 was AK able to make the arrangements that were necessary to begin production of his first dynamic speaker, the Model F. He had to arrange patent agreements, perform experiments, design the elements of the speaker and its protective enclosure, and set up production facilities in order to manufacture enough dynamic speakers to satisfy his market. At the same time, his engineers had to modify the output circuitry in the receivers chosen for use with the new dynamic loud speaker. The first receiver offered with a dynamic speaker was Model 43. Models 46 and 47 were supplied with Model F2 dynamic speakers.

AK electrodynamic loud speakers, such as Model F and Model F2, were self-contained, self-standing metal drums inside which the speaker frame and field structure were fastened. The difference in those two speakers was in the size of the drum-shaped enclosure. Model F was the smaller, about 10 inches in diameter, with a flanged front about two inches larger. Model F2 was a regular, slightly-flat horizontal cylinder a little over 13 inches in diameter. Acoustically, both speakers were the same.

The Model F electrodynamic loudspeaker was magnetized by a field coil wound with many thousands of turns of fine enameled copper wire, and connected to act as a filter choke in the power supply. Its voice coil measured a little over an inch in diameter, and was connected to a cone about 10 inches in diameter. The speaker worked reasonably well down to about 100 Hz. This was so much better than the type E magnetic speakers that it ushered in a new world of expectation of how a radio should sound. Part of the attraction was the increased power that the speaker could handle, and the rest was the extended low-frequency response. Present-day assessment of the sound usually leads to the comment "boomy," which suggests that the response peaked near 150 Hz.

MODELS 43, 46 & 47

The increased power that the dynamic speakers could handle had to be supplied by the radio, so revision of the output stage was required. This was done by changing the single-ended stage used in the Model 40 to a push-pull amplifier for Model 43. For the first time in the line of AK receivers an output transformer was used. It was used to change the small voice-coil impedance to the several-thousand-ohm loading required by the two output tubes. Room was made by removing the output choke used on the earlier sets. Because the extra output tube could not be fitted on the tube shelf with the other one, a second shelf was added to the right end of the power-supply enclosure opposite the rectifier. Aside from minor changes to the main power cable, increased supply capability of the main power transformer and substitution of the speaker field coil for one of the filter chokes, no other changes had to be made. No changes were made to the signal chassis, again exemplifying AK's precept of limiting changes while significantly increasing the radio set's appeal to potential customers.

The picture that emerges of AK's factory operations shows very effective control of the production process. Therefore, the engineers who converted Model 37 to Model 40 must have worked on that project early in the spring of 1928. Next came the work on the regulator for Models 42 and 44. After that they designed the modifications to the receiver that accommodated the dynamic speaker. Probably that work was completed in the fall of 1928. The radios that resulted were not only Model 43 but Models 46 and 47.

Model 43 was, in effect, Model 42 with push-pull type 112A tubes in its output. Model 46 was similar in having a push-pull output stage but it used 171A tubes, and omitted the primary-power regulator. It was an upgraded Model 40. Model 47 was the eight-tube set that was directly derived from Model 45,

were identical to the 30 series with brown panels. More puzzling was the fact that Model 48 appeared in both the form of the first version of Model 30 (bayonet sockets) and the second version (push-pins). However, both versions of Model 48 had the deeper cabinet first used on the third version of Model 30. Perhaps the market for battery radios continued at a high enough level to justify another production run for each set, but 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?

Model 45 was late enough in the sequence of the 40 series that it missed the 1928 holiday-selling season. The puzzle, however, is in its part number, No. 9880, which was assigned before those of Models 43 and 44. In AK's market planning, Model 45 may have been conceived but delayed. The part number tended to indicate the point where the idea was committed but the model number indicated when manufacturing functions, i.e., purchasing and factory planning, were turned on. Model 44 was the upscale (eight-tube) radio that was paralleled with Models 40 and 42. Model 44 was equipped with the primary-power regulator circuit. Model 45 was the direct replacement for Model 38 (upscale but no regulator) for those customers who wanted the more expensive receiver. But since Model 44 served the high end of the market, bringing out Model 45 along with Model 44 was not really good business. Model 45, when it was released, was one of the first radios in the AK line to be finished in the glossy near-black finish that supplemented the crinkle brown, standard in the 1928 series of sets. Perhaps Model 45 became part of the next year's line, replacing Model 44 with the new look of modern dress.

THE MODEL 50

In examining the sweep of AK radio receivers, the similarity of signal circuitry that any single set bears to other sets made at about the same time is striking. The underlying design was slightly modified many times, but it was not displaced from the time of the three-dialer (Model 10, 1923) to the last tuned-radio-frequency amplifier sets (Model 70 series, 1932) — except for Model 50.

Model 50, Fig. 46, provided three passive, coupled, tuning resonators to select the signal of interest before it was passed to detector level in a multi-stage, broad-band amplifier unit. The rest of the set was similar to other battery sets, e.g., Model 30. Analytical modeling of radio receivers (developed long after AK was out of the manufacturing business) shows that a better receiver can be built if it can select the desired incoming frequency from the spectrum of other signals and noise before any amplification is permitted. The part number of the set, No. 8500, indicates that it was first considered at the time of Model 33, perhaps as part of the effort to reduce the detuning effect of tube-replacement reactance in the ganged radio-frequency amplifiers of the 30 series.

To the technician interested in the history of receiver development, Model 50 is fascinating. To the historian interested in the growth of the radio business, radios like Model 50 are little more than ripples in the stream. From

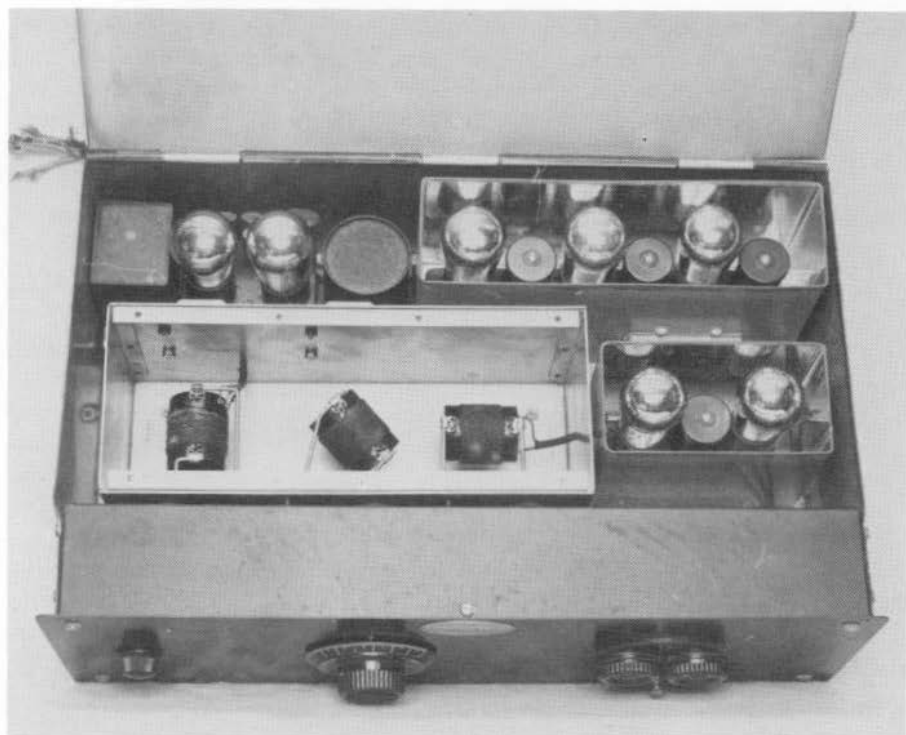


Fig. 46. Model 50

Photo: Alan Douglas

the small number of Model 50 receivers that have survived, the author concludes that AK saw no business value in including the set in his line of alternating-current receivers. The puzzle is: based on number sequences, the part number points to 1927 for design work, but the model number points to 1929. Did the concept drag on for nearly two years before the set was put on the market? Since it was late, and didn't sell, why did it appear at all?

CONSOLES AND THE "LITTLE STOVES"

In the mid-twenties the majority of the potential customers for radios preferred table models. The idea that radios were also furniture was still in the future. Some customers, however, wanted their radios to be self contained, so a secondary radio-receiver assembly business whose purpose was to meet those needs grew along with the general expansion of radio manufacturing. Usually the form of the radio enclosure was a self-standing console that carried the radio, the loud speaker and the power source. AK sold his radios to furniture companies, e.g., Pooley or Red Lion, who then assembled the complete unit and handled the marketing.

With the advent of the electric set, assembly into consoles became much more practical. As consoles became more popular, styles and suppliers proliferated.

AK resisted the trend, possibly because he preferred the cabinet set, but more likely because he had become a high-quantity producer of metal-enclosed radios, and console production was a specialty business based on wooden furniture. To accommodate the console suppliers, AK provided complete cabinet sets, case and all, which were hidden behind a fancy panel. Cutouts in the panel provided access to the controls. Model E loud speakers were redesigned by eliminating their cylindrical cases and providing a flange around the cone. Modification of the dynamic speaker was not necessary. AK simply supplied the loudspeaker without its enclosure. The plain unit was identified as Model F-2C. (C indicated use in a cabinet or console).

At about the same time as the 40 series was put on the market in the form of table-model receivers (with some being incorporated into consoles), AK redesigned their steel cabinets to make them into free-standing floor models. Short legs were attached to the bottom of the resulting rectangular box, thereby placing the dials at a convenient height, about 27 inches above the floor. The extension (the space below the radio) was used to house the loudspeaker, making the first fully integrated series of radios in the AK line. The pressed-steel consoles corresponded exactly to cabinet sets in the 40 series. They were assigned model numbers in the 50 series. Model 51 was a direct-current radio that was identical to Model 41. Model 52 was the same as Model 42.

Model 53, Fig. 47, is a little more interesting to collectors. The electrical circuitry was the same as Model 43, including the dynamic speaker. The console



Fig. 47.
Model 53 Console

Photo: R. Williams

for Model 53 was four inches shorter than the other two, perhaps to make a chairside radio. (The set would have been just right to use with a Morris chair.) The Model 53 was offered in several different paint combinations; brown crinkle with gold, gloss black with green, and medium green with gold pinstriping. To the contemporary homemaker, the radio was an interesting and apropos addition to the living room. To the present-day observer, the design is so strange that these consoles are referred to as "little stoves". There were two others, Model 56 and 57. Both used the circuitry from Model 40 (no regulator). Model 56 was the taller and looked like Model 52; Model 57 used a lower cabinet that was similar to Model 53.

THE SCREEN-GRID TUBE AND MODEL 55

During the first World War (1916), German tube researchers, particularly Schottky, studied the triode and the effects of extra electrodes on its performance. Their work led to accurate characterizations and some use by the German military, but it was not used by American tube manufacturers to develop a commercial tetrode until the middle twenties. When it appeared in 1926, the D.C. filament version was designated UX222. For electric radios, the further development of the tetrode to incorporate the unipotential cathode was necessary. That work took place in 1928 and the result, the UY224, was announced in April, 1929.

One result of the 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. 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 the 224 available in the summer of 1929, AK brought a radio to market using that tube. It was designated Model 55.

The opportunity to develop a new line of radio receivers which was brought about by the introduction of the screen-grid tube caused a major stir in AK's engineering activities during early 1929. A whole list of requirements had been accumulated; here was the opportunity to meet them. For the first time in nearly five years, the radio amplifiers in AK's receivers could be redesigned (of course the tuning condensers, the tracking bands and the general layout were 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. Mechanical integration of the power supply in the total radio enclosure was a requirement that had been met only marginally in the 40-series electric sets. Console radios had become prevalent enough by the middle of 1929 to make it necessary to include their requirements in any new design.

Taken altogether, these new demands, the results of earlier successes, called for a totally new mechanical design. The days of the steel cabinet were

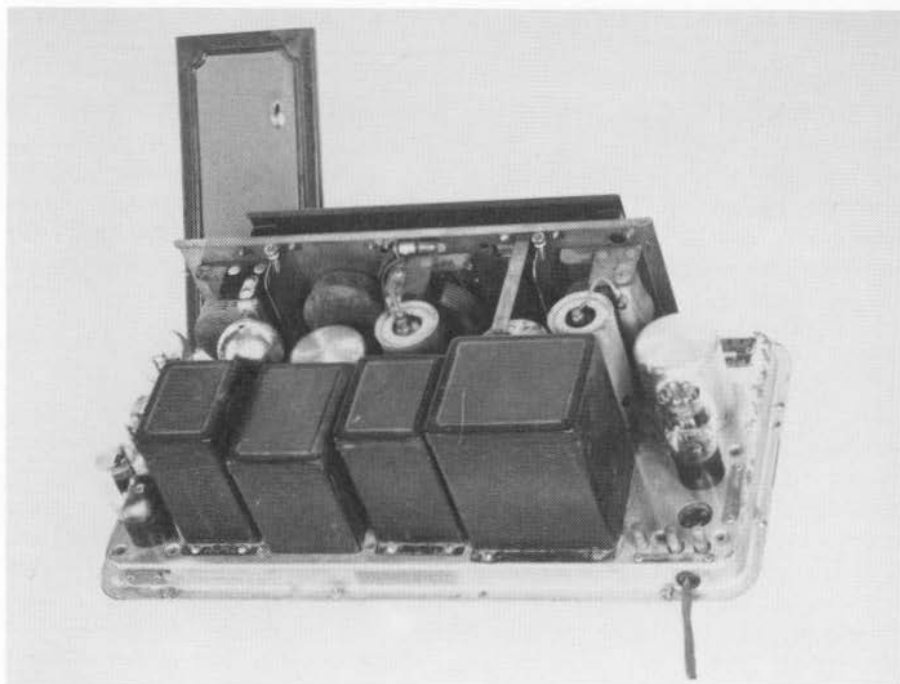


Fig. 48. Model 55 Chassis

Photo: R. Williams

numbered, but the superb metal-shaping facilities that AK had developed were still in place. Integrating all the demands in a new, producible, easily-assembled mechanical structure called for another first in the AK line of radio sets. It was the concept of a planar chassis with shallow, stiffened edges, whose strength was sufficient to structurally support all the components in the receiver during assembly and shipping. Its shape was selected to simplify fabrication, and its size (10"x21") was chosen to fit into the steel cabinet used for Model 45. The radio that was built upon this new chassis was Model 55, Fig. 48. When the radio was to be supplied in the metal cabinet, the controls passed through penetrations in the front of the enclosure in a manner similar to the 30 series. AK, realizing the trend toward wooden floor-consoles, arranged the design of the chassis to accommodate a metal dress-panel through which the control shafts passed, and on which the dial escutcheon was mounted. The panel was finished in simulated wood-grain. It was used to close 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.

The power supply and the audio circuits for Model 55 were adapted from Model 46 with minor changes, e.g., the output tubes were changed to type 245 and the filament circuits for the whole set were 2½ volts. The big change was the use of 224 tetrodes as radio amplifiers. This increased the stage gains (and improved selectivity) enough to make a power detector practical. The result was a very sensitive electric radio with higher output power and lower harmonic distortion than anything AK had produced before. Model 55 became

the main sales attraction for the 1929/30 holiday season. It was with this radio that AK started his campaign to emphasize "Tone".

By 1930, radio had become a vital part of American life. The broadcasting networks had matured to the point where their programs were shaping the way people arranged their lives, i.e., news at the supper hour, programs in the evening. AK utilized the growth of broadcasting to build his proud product image. He sponsored a serious music hour that was broadcast on Sunday nights over a coast-to-coast network of 31 stations. To reach another segment of his customer audience, he offered a mid-week program of popular music over a smaller network of eastern and mid-western stations.

MODELS 60, 61, 66 & 67

In the same way that Model 44 paralleled Model 42, Model 60 was the upscale version of Model 55. The chassis and the arrangement of the tuning condensers used on Model 60 were similar to Model 55, except for the addition of another radio amplifier. AK advertised Model 60 as being more sensitive (than 55) but the text was careful to indicate the benefit was for rural areas. In general, the contribution of the extra stage was cancelled by the volume control. In 1930 AK made a big change in the way he built the radio-amplifier stages of his radios. He went away from the tracking bands (his patent) to the use of a single-shaft, multiple-section variable condenser (J. V. L. Hogan's patent). This change resulted in a mechanical redesign of Model 60 which was designated as the "3rd type."

In 1930 the number of listeners who needed direct-current radio receivers was still large enough for AK to produce brand-new sets for that market. The customers divided into groups; those who had direct-current housepower, and those who needed a battery-powered radio. For both of these users, AK modified the Model 60 to use type 222 tetrodes, type 112A triodes and type 171A output tubes. The radio to be used on the direct-current mains was Model 61. The battery version was Model 67. The differences between the sets were in the power supply and the loudspeaker field coils. Model 61 filtered the mains and used a Model F6 speaker with a high-resistance field. Model 67 used A and B batteries with speaker Model F7 (field operated from the 6-volt A battery).

The last set in the 60 series was the high-powered member of the group, Model 66. It was very similar to a plain Model 60 except for the output; Model 66 used push-pull type 50 tubes. The demand on the rectifier tubes exceeded the capability of the type 80, so a pair of type 81 half-wave rectifiers was used. Model 66 was not offered in the metal cabinet that had become AK's symbol. Because it was sold through the console manufacturers and offered so much power, the author suggests that it was built for the custom market.

THE 70 SERIES

The concept of introducing a new series of AK receivers annually was well established by the year 1930. To be ready for that year's holiday-sales season,



Fig. 49.
Model 75 Radio-Phonograph

Photo: R. Williams

a new series of receivers had to be made ready. According to AK's precept of minimum technical change and, at the same time, responding to customer preferences, the new line (the 70 series) was derived from the Model 60, especially the third version with the multi-section tuning condenser. To provide a wide range of choices to his customers, AK provided six different chassis types and four enclosures, all consoles. One console was a radio-phonograph, Model 75, Fig. 49. Clearly, AK had gotten the message about the marketability of console-model radios.

At this time, a customer who wanted to buy a table radio bearing the AK name had to accept an earlier model. Looking back from the view point of another half century, not offering a cabinet set in the 70 series might seem to have been arbitrary on the part of AK and his staff, since we know that compact receivers were about to become popular. More likely, the 1930/31 season was the crest of a wave that gave great status to having a radio, and greater status to having an AK. The very bad situation that started with the stock market crash of 1929 had not spread to the class of buyers that were AK's main focus. The country tried to keep the romance of the twenties alive as long as it could, and only doom-criers took comfort in the financial and commercial downturn that was about to overtake everyone. From AK's standpoint, opening a new low-end market might have been nearly impossible, since he announced set number 3,000,000 in October 1930. At that time he was producing at the rate of 50,000 sets per month. It may be suggested that there was no point in AK's doing anything else since he was riding the top of the wave. This evaluation fails to account for AK's demonstrated business vision and market perception.



Fig. 50. Model H-1 Superheterodyne Chassis

Photo: R. Williams

Electrically the radios type L, (10-tube TRF), type F (25 Hz), type D (D.C. mains), and type Q (battery) were unremarkable if compared to the preceding Models 60. They had one interesting mechanical feature, however. The chassis was punched out in two 12"x10" pieces, each a little more than one-half the size of the Model 60 chassis. The joint between halves ran from front to back and provided an immediate identification detail. The half-chassis would have required smaller presses than those used to form the Model 60 chassis. Some of the presses used to make earlier cabinets could have been used to make 70-series chassis-halves while the Model 60 presses were still busy.

Another chassis, type H, Fig. 50, was provided as an option to Model 70 series customers. This one was very different; it was the first superheterodyne produced by AK. Fig. 51 shows the early version of its circuit. For nearly a decade the patent rights to the superheterodyne had been held (tightly) by the Big Three, more specifically the Radio Corporation. As one of the many results of the separation of RCA from GE and Westinghouse, the licensing of the superheterodyne patent was extended to all interested manufacturers. Whether the circuits based on the superheterodyne were better than the TRF circuits was an argument among technicians. The clear advantage was in the manufacturing costs for radios of equal performance that were built to be used in the home.

AK's first superheterodyne did not take advantage of the cost reductions, however, since it was really an adaptation of the TRF in mechanical and circuit details. As later designs demonstrated, selectivity in a superheterodyne was obtained from the transformers in the intermediate-amplifier stages. The first version of Model H used three sections of the variable condenser in a passive tunable filter (more than a little reminiscent of Model 50) to do the same job that the intermediate-frequency amplifiers could do. That version, H-1, used separate, uncoupled chokes and coils in the intermediate-frequency amplifiers. The second version changed the chokes to double-tuned transformers whose coupling was controlled by their mechanical spacing, in what became the standard design.

All the receivers in the 70 series performed well. They were sensitive, powerful and provided good tone. In part, the tone was the result of the cabinet size and its resonance. The quality of the sound led the advertising people to dub the 70 series as "The Radios With The Golden Voice." This feature was pushed very emphatically in print and radio advertising, especially by programs given in the sixth year of the AK Hour on the national radio network of 34 stations.

THE 80 SERIES

The impact of licensing the superheterodyne patents from RCA was total revision of the AK product line. Although the new circuit was first introduced as a single set, the type H chassis in the 70 series, it presaged a major change in the radios in AK's 1931/32 product line, the 80 series. All of the radios brought out for the 1931/32 model year were superheterodynes except the auto radio, Model 81. Specifically, eight models made up the 80 series of superheterodynes, but many of these had AK-standard suffix letters to indicate their application. The total of all variations was 21. Three were compacts; Models 80, 82, and 84. The others, Models 83, 85, 86, 87 and 89 were consoles whose enclosures were offered as lowboys and highboys, some with doors, and one as a phone combination.

Analysis of the 80 series and its predecessors shows the continuity of the AK product line and its response to market conditions. Until 1931, the product line was targeted at the upper-middle segment of the total radio market. By then, however, customer preferences had changed enough to significantly reduce the business potential of that segment. AK responded by using the substantially less costly superheterodyne circuit and by offering the compact sets. ("Supers" were cheaper to produce because they did not require the difficult tracking-precision that characterized the four-resonator TRF). The style of the first compacts was established by other manufacturers, for example, Philco. AK's product designers followed the others, albeit interpreting richness into their designs.

The electrical and mechanical designs of the compacts reflect substantial cost reductions from the consoles, but no reduction in quality. The chassis was reduced in size (9"x14"), Fig. 52, and changed to a folded shape, instead of

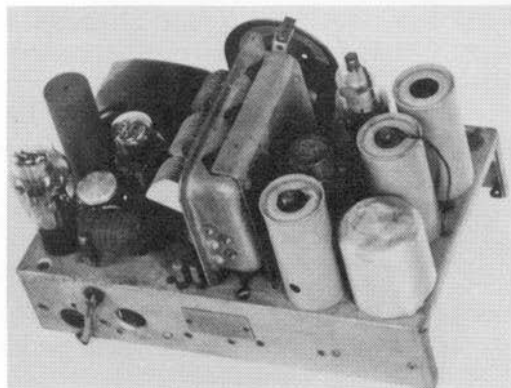


Fig. 52.
Model 84 Chassis

Photo: R. Williams



Fig. 53.
Model 84 Compact

Photo: R. Williams

being a large stamping. Full advantage was taken of the cost advantages of the superheterodyne circuit. Model 80 was a no-frills, five-tube-plus-rectifier radio offered in a dressed cabinet. Model 82 added a control tube and made the cabinet a little more gothic in style. Model 84, Fig. 53, used the same circuit as Model 80 with a plain version of the cabinet from Model 82.

The large chassis that was used in all the consoles was based, mechanically, upon the stamped chassis that was introduced for the third version of Model 60. The superheterodyne circuit of the 70 series, type H-2, was the electrical base for the series. The order of complexity (and the price) in the series of consoles followed the model numbers. Model 83 had six tubes and used a single type 47 output tube. Model 85 added an automatic volume control tube, and Model 86 went further with a radio-frequency amplifier. Model 87 provided pushpull type 47s in the output but deleted the control tube. Model 89, Fig. 54, did it all: RF amplifier, IF amplifier, two detectors and their oscillator, low level AF amplifier, automatic volume control, pushpull-pentode output, and a rectifier.

In the 80 series, AK introduced what was, for his product line, a brand-new concept, the auto radio. It was identified as Model 81. The circuit was a seven-tube TRF, including a volume-control tube, using the newly introduced series of six-volt heater tubes, types 36, 37, and 38. Type 36 was a tetrode used for the three radio-frequency amplifiers. Type 37 was a triode. It was used in two places; the detector, and the control tube. Two type-38 pentodes were used in a pushpull-output circuit. The auto radio was powered by A, B and C batteries carried in a separate container. The heaters and the speaker field were powered from the six-volt auto battery.

Model 84 was the most popular of the compacts, and, because of the reduced sales of consoles as compared to compacts, the most popular set in the 80 series. Model 84 pointed the way to the future, but history has indicated that it



Fig. 54.
Model 89 Console

Photo: R. Williams

was not heartily welcomed by AK. Meeting the new market at the levels that had characterized the company for the past several years meant a very large, uncomfortable change in the way business had to be done.

THE 90 SERIES

By the middle of 1932, business conditions in the United States were depressed enough to change the radio market from the crush of credulous fans in the middle twenties to a highly discriminating audience that balanced finances against the appeal of a new radio set. Manufacturers realized that they had to appeal very strongly to potential buyers. One way was by the introduction of more new models than were offered in the annual campaign at the holiday season. AK's mid-year appeal in 1932 was the group of radios that made up the 90 series. These were very similar to those in the 80 series, and corresponded in Model number with certain exceptions; Console Models 83, 87 and Compact Model 84 were dropped and Console Model 85 became Model 94.

A new feature was offered in Model 93, Fig. 55, a short-wave tuner. This was a four-tube unit made up of a mixer, a local oscillator, one stage of IF amplification, and a rectifier. The tuner made three short-wave bands available at a converted frequency of one MHz, to which the main receiver was to be tuned.

The top consoles in the line, Models 96 and 99, were modified from their earlier counterparts by the addition of a tuning indicator. It was a glow tube



Fig. 55.
Model 93 Short-Wave Tuner

Photo: R. Williams

connected in the plate supply circuit for the RF and IF amplifiers. When first identified, it was called a "Neon Tuning Light." The sales potential of the new indicator was not missed by AK's marketing people. They set up a national contest with a first prize of \$1000 to select a name for the new AK feature. The name that became the advertising keyword was "Tonebeam".

Not all of the earlier variations were carried into the 90 series. The 25-Hz power-transformer substitution (suffix F) was available for all compacts and consoles, but the battery and the direct-current variants (suffixes Q and D) were not updated. The auto radio, Model 91, was redesigned as a superheterodyne. It had nine tubes, included AVC, was offered in three configurations to accommodate different installations, but still used batteries for its B and C sources. With the auto radio becoming a superheterodyne, AK took maximum advantage of a reliable, conservative manufacturing and engineering base for his company. The circuit was standard and it was very easy to add and remove features like push-pull or single-ended output. Three lines of chassis fabrication had been established: the auto radio, the compact (9"x14"), and the console (12"x21"). The big changes that had to follow the 90 series were market-based, and were in the area AK liked least, enclosure appearance. Wooden cabinets and dependence on cabinet suppliers were not his favorite concerns. It appears to the author that the elements of the business that AK found most rewarding to his creative talents were reduced to near-routine and that, consequently, his enthusiasm was threatened.

RECEIVERS WITH THREE-DIGIT MODEL NUMBERS

In studying AK receiver production, the idea recurs that the Company's life can be visualized in two periods. The first period seems to have ended in 1932, and has been described in these articles as Development. The second period seems to have been characterized by Maturity (in a business sense) and went from 1932 to the cessation of production in 1936. A very strong indication for this idea was the way the chassis developed from the panels in the mahogany sets, embraced the metal cabinets, became a very large structure (for radio sets), and then after 1932 was only resized downward. Another was the way that the appearance of the sets changed in going from the Open Sets, through the Mahogany and Metal Boxes, to the Compacts and Consoles in only ten

years. After 1932, styling seemed static. Still another was the change in service literature. It went from none for the early sets, through complete texts in the late twenties, to sketchy supplements issued in the later period. Future studies, hopefully inspired by these articles, may find that the strongest evidence for the two periods was the radio market itself, particularly as it changed in the depression. The story of the mature period should be told differently than the way that has been used for the development period. Some suggestions have been included in the following quick review.

A technical change that also occurred in 1932 has frustrated servicemen (and AK collectors) ever since. During the development period there had been strong, although not exact, correspondence between the first digit of the model number and the year of manufacture, but the sets made during the mature period no longer used that system. Three digits were used to identify all the sets made after late 1932, but the assignment of the first digit did not appear to be systematic. The third digit of the model number was used to state the number of tubes in the receiver. For sets having ten or more tubes the last two digits were the tube-count identifiers. Consoles were sometimes identified by using a suffix letter, and the earlier power-source suffixes were continued with their original meanings. It seems that the convenience of identifying years was traded for the ease (sales advantage?) of identifying tubes. The author has tried to correlate the first and second digits of the model numbers to advancing time (production year) without success. Since the early system has shown itself to have been effective, and the three-digit was faintly chaotic, the author has difficulty avoiding the idea that this too marks a difference between the development and maturity periods.

Because there were more than 165 similar receivers manufactured between late 1932 and 1936, a story of their minor differences far exceeds the purpose and scope of this article. Up to 1932 the AK story has been told by reviewing the year-by-year developments, but when this method of portrayal was tried for the three-digit series, the rendering was dull and unsatisfactory. The story of the receivers of the mature period might be better told by relating their characteristics and the market conditions at the time of their introductions, in a form suited to graphic presentation. As an example, the circuit for all three-digit series was the same superheterodyne used in the 80 and 90 series, with variations such as the number of amplifier stages and application of newer tubes as they became available. The correlation of these features seems stronger to marketing advantage and pricing than to technical development.

Another aspect of the mature period was the mechanical story; chassis sizes and dials. The development of the big chassis and its continued use has told much about the development period, but for the mature phase when smaller, less-expensive chassis were introduced, a chart of sizes and applications would provide a better basis for understanding the business. Fig. 56 pictures the radio considered to be the biggest (and best), Model 812, sold in 1933. Fig. 57 shows its 12"x21" chassis. For comparison Fig. 58 shows one of the smallest sets, Model 275, an A.C./D.C. receiver from the 1934 season. In Fig. 59 its 5"x10" chassis is shown. The problem of relating the characteristics of all the sets becomes clear when it is remembered that there were 165 between these two.

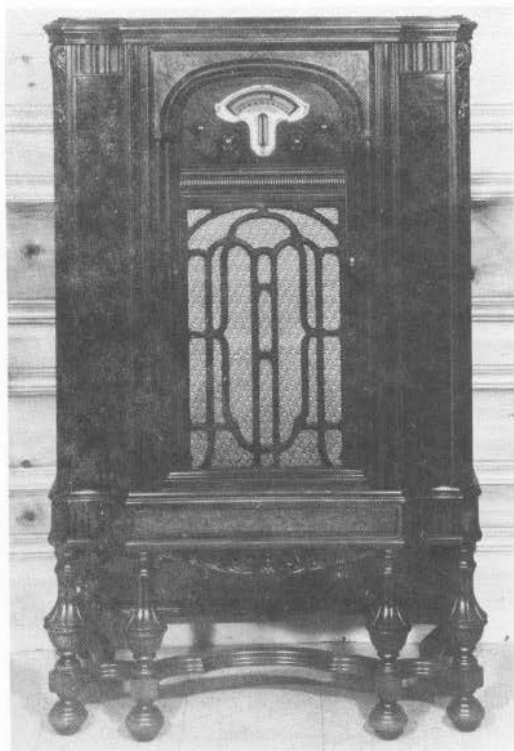


Fig. 56.
Model 812 Console

Photo: Alan Douglas

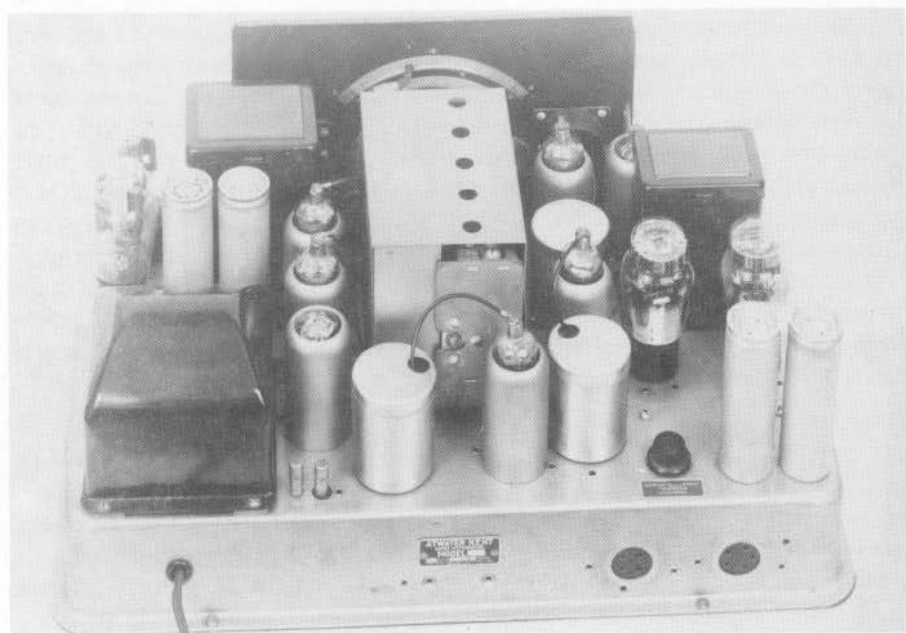


Fig. 57. Model 812 Chassis

Photo: Alan Douglas



Fig. 58.
Model 275 Midget

Photo: R. Williams

Most of the radios built during the mature period were fitted with airplane dials. The earlier dials were 3" in diameter, and quite plain, but later sets were equipped with larger dials that lit with different colors to indicate the wave bands selected by the listener. A story is told that AK particularly disliked the airplane dials because he felt that the listener sitting in his chair should be able to see the dial setting, and that only the fan dials met that requirement. A tabulation of the sets that used window, fan, and airplane dials along with the chassis and the enclosure date for each set might be helpful to collectors in recognizing the breadth of the product line manufactured during the mature period.

Console styles changed very little in the early thirties. The biggest change was doing away with the console legs in favor of a full-height columnar motif. Changes in the compacts were a little more apparent, but in the very conservative AK line, they were small. The biggest change was going from the rounded top, that had started with the gothic arch in 1932, to the flat tops that came out in 1933 and were produced through the entire period. The cabinet story is almost a description-of-reuse based on slight circuit or tube variations, and responsive to the price-conscious market. The clear development progress that characterized the early period was no longer apparent with the three-digit series.



Fig. 59.
Model 275 Chassis

Photo: R. Williams

CONCLUSION

The reflections that come to us from the record, from the recollections of AK's employees, from descriptions sketched by close acquaintances and family, and from the technical chronology provided by his radios, tell of an outstanding early-twentieth-century manufacturer. The factory floor with its people, its product flow and its potential for increased business appears to have been a living reality to AK. He was interested in his employees, concerned with their well-being and fair in his treatment of them, but not indulgent. He set high standards for himself and expected his organization and the people around him to live up to his standards. He was very aware of his personal and commercial images, diligently protecting both by avoiding publicity about himself and his family, and by hewing carefully to the business standards of his time. Near the close of manufacturing operations in 1936, a group of his technical, marketing and manufacturing people approached AK with the idea of buying the Company and independently continuing in the radio-manufacturing business. He refused their offer, giving the reason that he could not sell his name because he could not be sure of its preservation.

The remarkable styling of the AK radio lines through the twenties illustrates the interplay of the man's strong creative personality with the evolving radio market. Company growth through the twenties and the first two years of the thirties attest to AK's acuity and resilience in shaping both the product and the market. The next two years can be read in two antithetic ways. The first (which the author rejects) suggests that AK backed away from the business and in 1936 gave up when the unions made image-demeaning demands. The flaw in this thesis is that AK had solved problems, far larger than those resulting from accommodating the mid-thirties changes in labor relations. Several former employees, in being interviewed, did not attribute the factory closedown to labor trouble, but to decreased markets.

The second thesis suggests that the same acuity, with which AK perceived the growth potential that resulted in his becoming the world's leading radio manufacturer, signalled the major changes that were coming in making and selling high-production radio sets. Midgets and medium-sized table models had virtually eliminated high-priced consoles. The market (in dollar volume) had decreased substantially and could not be expected to provide even moderate loading of the company's facilities, much less keeping it going at its former level. Radios changed from substantial (comfortable) furniture to gadgetry (treasure chest), with the result that the distribution and selling part of the business moved from conservative, old-line furniture stores to bargain, appliance vendors. Because radio marketing and production changed so drastically, AK recognized that continuance was really the building of a new business.

The political atmosphere of the middle thirties was hardly friendly to resolute, independent capitalists. AK had been struck from that mold and was, consequently, unwilling to accept what he felt was governmental regulation of his life (the Company). With four cycles of eminent business success, he decided not to go around again. Interestingly, the record indicates that AK (virtually alone) did not reinvest the returns earned in the twenties to keep going, only

to lose out later (Freed-Eisemann, Grebe). Instead, he chose to liquidate the factory and its tool while retaining the Company's good name and his personal fortune. Much of the charitable work done by the Company, to this day, owes its continuance to AK's choice to leave the radio business.

Shortly after the factory closed in late 1936, AK left the Philadelphia area to make his home in California. He settled in Belair (an affluent suburb of Los Angeles) where he was able to enjoy some of the pleasures that he had set aside during his business years. In the succeeding decade, AK earned a small reputation as a party-giver in the style of the movie-greats, but that was the extent of his public interaction. Until his death in 1949 AK spent his time quietly, away from politics and industry. His activities included furthering his appreciation of automobiles and his interest in boats.

AK's need for privacy, and his reluctance to treat his radios as important historical artifacts, have left only the sketchiest picture of the man and his life. As the perspective offered by the passage of time grows, it becomes ever clearer that Arthur Atwater Kent was one of the great figures of the twentieth century. Perhaps these articles about AK and his achievements will help to uncover more material about him. Let us try, as historians, to be as effective in educating his story as he was in bringing AK radios to the twentieth-century world.

Ralph O. Williams

Born in Nov. 1920, coincident with KDKA's first broadcast, Ralph attended high school in N.J., followed by Cooper Union College. When WW II 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 varied 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 a master's degree in engineering science; his thesis was on the information-processing efficiency of the Morse telegraph code. After retiring from G.E. in 1980, Ralph moved to Orient, N.Y., 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.

