BY MARC ELLIS

Evolution of the AC/DC Set

WE BEGAN DISCUSSING SCALED-DOWN-FOR-THE DEPRESSION "MIDGET" RADIOS IN THE APRIL, 1999 ISSUE OF **POPULAR ELECTRONICS**. THEN, IN THE MAY ISSUE, WE DROPPED THE SUBJECT TEMPORARILY TO DISCUSS PHILCO'S MUCH LESS drastic approach to depression downsizing, which led to the development of the very popular (and far from small) "cathedral" radios. Now it's time to return to the original story thread and trace an important line of radio evolution which began with the first "midgets."

The International Kadette Universal

Back in that April column, the "International Kadette Universal" (definitely a midget) was presented as what was probably the first of a very influential design that became known as "AC/DC" Let's review the meaning of that term.

The Kadette used only three tubes (excluding rectifier). The reason it could get by with so few was that the tubes (types 39, 36, and 38) were from a newly-introduced (in 1931 and 1932) high-performance series designed for auto radio service. Two of those (the 39 and 38) were of the new "pentode" design that offered greatly enhanced performance with little or no increase in parts count. See the April, 1999 **Popular Electronics** "Antique Radio" column for a schematic of the Kadette.

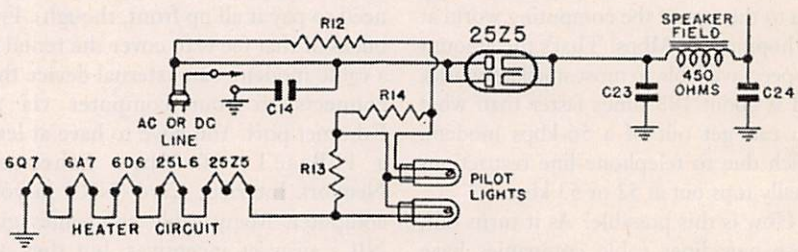
As part of the strategy for eliminating the large and expensive power transformer, the heaters of the three tubes were made to operate directly from the AC line. This was done by putting the three 6.3-volt heaters in series, like an old-fashioned set of Christmas-tree lights. In that configuration, they required 18.9 volts to operate. Placed directly across the AC line, the string of tubes would of course immediately burn out. However, a 310-ohm power resistor, mounted under the chassis, was included in the series string to drop the line voltage by about 93 volts more.

Because there was now no power transformer (a device that could operate only on alternating current), the Kadette could operate from DC as well as the AC line. In those days, the downtown sections of many large cities were still supplied with DC current, which had to be converted to AC by various means to operate common appliances and motors. While this wasn't really a very big market, AC/DC operation was still a useful selling point and radios with series string heaters became known universally as "AC/DC sets."

This system probably wouldn't have even been considered had the auto tubes with their 6.3-volt, 0.3 amp heaters (designed to operate with minimal drain from the storage batteries of the day) not been available. The 2.5-volt 1.75-amp range of tubes then common in home radios would have required a much heavier series resistor to drop the larger voltage at heavier current. As it was, several watts of power had to be dissipated in the resistor. Power dissipation means heat dissipation, and things get hot enough under the chassis to shorten the life of capacitors and other components.

Cooling-Down Strategies

The heat problem was minimized through innovations on several different fronts. First, the "below decks" power resistor was very soon replaced by one of two devices: (1) the "ballast resistor," which looked like a metal tube (sometimes with heat-releasing perforations in its metal shell), plugged in atop the chassis like any other tube or (2) the line-cord resistor, which was an extra conductor—made of resistance wire—built into the line cord. In both cases, the heat generated by the resistance element was prevented from overheating the space beneath the chassis. However, it's not unusual to find ballast sets with cabinets discolored (or even charred) by heat



A TYPICAL AC/DC power-supply circuit. The heaters of the five tubes are in series; R12 is a ballast resistor; pilot lights operate from a separate tapped resistor. The speaker field coil doubles as filter choke.

generated above the "tube."

The line cord resistor has often confused new hobbyists who may replace it, when frayed, with an ordinary two-wire cord. The result is a dead radio and (depending on which two of the three connection points in the set is used for the new cord) possibly a set of tubes with blown heaters. In attempting to replace the plug on such a cord, neophytes may also either ignore the fine and easily broken resistance wire or tie it to the wrong side of the line. In either case, though no damage will be done, the tubes will not light.

Cords with line cord resistors can be recognized by their fatter-than-usual cross section and (usually) cloth outer covering. Often this covering is frayed in places, exposing the asbestos insulation underneath. If a frayed cord is in working order, don't be tempted to replace it. Resistor cords are hard to come by—though there are alternatives that can be discussed in future articles.

Tube Evolution in AC/DC Sets

Another innovation was the introduction of tubes with higher heater voltages. The first ones to appear were audio-output tubes such as the 25L6 and rectifiers such as the 25Z5. Tubes in those categories, because of the greater power that they handle, could especially benefit from the greater heater output made possible by the higher operating voltages.

It's not uncommon to find early AC/DC sets with a 25-volt rectifier tube and three 6-volt tubes or with 25-volt rectifier and audio-output tubes and two 6-volt tubes. In either case, significantly less power needed to be dissipated in the ballast or line-cord resistor to drop the remaining voltage.

Among the six-volt tubes providing the detector, RF-amplifier, and AF-amplifier functions in sets with line-cord or ballast resistors and two 25-volt tubes as described are the types 39 and 36, the later types 78 and 77, or the still later 6C6, 6D6 and 6Q7. Six-volt power output tubes in sets not equipped with a 25-volt version are typically type 38 or the later type 43. When five-tube superheterodyne circuits began to replace the four-tube tuned radio-frequency designs, the 6A7 pentagrid converter (also six-volts) began to appear.

As the five-tube superhet circuit became standard in the late 1930s, a whole new series of tubes, all with high-voltage heaters for series heater-string operation, emerged. One configuration was so commonly used that it became known as the "All-American Five." That set was made up of a 12SA7 pentagrid converter, 12SK7 RF/IF amplifier, 12SQ7 detector/amplifier, 35L6 power output, and 35Z5 rectifier. Note that the heater voltages (first two digits of the type number) add up to 106, which was close enough to the nominal 115-volt line voltage so that no ballast or line-cord resistor was needed.

Other AC/DC Design Features

As has been mentioned in some of the earlier articles on this subject, other changes were also made in the power-supply circuitry in order to reduce size, weight, and cost. Among the earliest simplifications was to substitute the field coil of the dynamic speaker then in common use for the power-supply filter choke. The coil substituted for the choke while at the same time receiving the energizing voltage required for the speaker to operate.

Still later, the development of efficient permanent-magnet speakers rendered dynamic speakers obsolete and field windings disappeared. By that time, however, inexpensive high-capacity electrolytic filter capacitors were available. Using them, filtering action became so much more efficient that a power resistor of a few hundred ohms could be substituted for the choke.

By now, improved tubes and circuitry had made sets so sensitive that the traditional hank of antenna wire, unrolled under a rug or tossed out the window, became unnecessary. A neat, self-contained loop antenna, usually mounted inside the back of the cabinet, was enough to do the trick.

Changes in cabinet design also rate at least a brief mention. The original midget sets were housed in compact wooden cabinets. Made to sell as cheaply as possible while yielding a profit for the manufacturer and dealer, very little thought or money was expended on the radio's looks. Nevertheless, many of these wood cabinets had a kind of naive charm that I, personally, enjoy.

By the early 1940s, more and more cabinets were being made of plastic. This material (usually Bakelite either left in its natural brown color or with a painted finish applied) was easy both to mass produce and to mold into the "streamlined" rounded shapes favored during that era. Also, the newer generation of tubes were about half as high as the types used in the original AC/DC sets, allowing for the cabinet to have a lower, sleeker profile. More attention began to be paid to the aesthetics of the cabinet, and the inexpensive sets began to have a more sophisticated look.

Catalin plastics, which could be produced in a variety of glowing colors, were also sometimes used. Catalin cabinets are fragile and become more so with age, often cracking spontaneously because of internal stresses in the material. Catalin cabinets are rare, especially in flawless condition. They are much prized by some collectors today and a Catalin radio that sold for $19.50 in 1940 might well change hands at $1000 today!

BY THE 1940s, inexpensive plastic-molding techniques were making it possible to mass produce cabinets with a sleeker, more sophisticated look.

Military Radio Collectors Take Note!

I recently received a query from Major (Ret.) Richard J. Blondis, 291 East Calle Herboso, Green Valley, AZ 85614; Tel: 520-393-0922. The Major has a World War II German military shortwave radio gathering dust in his storage area. He'd like help valuing the set and figuring out how to market it. The markings on the set are: *Telegrafen Werkstatte, Musterr RV 14, Serie II Number 151.* Contact Major Blondis directly if you can assist him or if you are personally interested in the radio.

That's it for this month! We'll see you in July. In the meantime, send your comments and suggestions to me at "Antique Radio", c/o **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735-3931. Or use my personal e-mail address: ellis@interaccess.com. Regretfully time limitations do not always permit me to respond individually. But all correspondence will be read with interest and acknowledged in the column. EN