# Substitutes for the WD-11

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***W***estinghouse introduced the WD-11 tube in 1922 for their Aeriola, Sr. (Model RF). They needed a tube which could be heated with dry cells instead of storage batteries. The WD-11 was also used in the RS, Regenoflex, Radiola X, Radiola III and Radiola III-A, sets made for RCA by Westinghouse. The development of this tube is well documented [1].

General Electric developed the UV199 tube independently, with the same objective of economical dry cell operation. The UV199 was introduced in 1923 with the Radiola IV. Its characteristics were similar to the WD-11 except for the filament demand of 3.3V/.06A vs. 1.1V/.25A for the WD-11. Besides its filament economy, the UV199 was also more robust and less microphonic.

The filament structure of the WD-11 is notoriously delicate. When a filament burns out, it may flop against the plate applying B+ to the filament circuit with disastrous results [2]. RCA chose the UV or UX199 for subsequent superheterodyne and regenerative receivers. No apparatus using the WD-11 was designed after 1924, and it became obsolete so quickly that RCA issued Service Bulletin #6 (Dec. 11, 1925) showing how to convert the Radiolas III and III-A to UX199 and UX120 tubes [3].

Westinghouse issued the WD-12, a UV-based version of the WD-11, in 1923. It was replaced by the UX-based WX-12 in 1925 for converting storage battery sets to dry cell operation. The Crosley "Pup" appears to be the only radio factory-designed for the WD- or WX-12. The WD-11 and WX-12 were dropped from the official RCA product line in 1933 [4].

Those who want to play these early sets have a tube problem. RCA quit stocking WD-11 tubes 70 years ago. Today they are prohibitively expensive, being worth more than the radios using them. Because of their value, those who have WD-11s are reluctant to put them into service.

UX199s can be used per the RCA bulletin. Adapters are still around, but both are quite expensive. The 864 (VT-24), developed for aircraft use, is a popular substitute because it has the same filament requirements and similar characteristics, but is also now quite expensive.

The Type 30 has been used as a substitute, but is both expensive and requires an oddball filament voltage. Another substitute is the Loctal 3D6, a beam pentode, connected as a triode and used with an adapter. Its filament requirements are similar to the WD-11. Miniature pentodes (1L4, 1S4, 3S4, 3Q4, 3V4) used in the same manner have also been described [5].

Another elegant solution is to use a miniature, wire-lead 5676 in a WD-11 base. A silvered test tube can be fastened over it over it to give the appearance of a WD-11.

**Testing Possible Substitutes**

I decided to carry out some tests on possible substitutes that would be cheap, plentiful, functional and resemble the WD-11. A look at the tube manual uncovered the following possibilities:

| Tube | Fil. V/A | Bias V | Plate mA | Gm | µ | Base | Price-$ |
|---|---|---|---|---|---|---|---|
| WD-11 | 1.1/.25 | -4.5 | 2.8 | 400 | 5.6 | Unique | 100+ |
| 864 | 1.1/.25 | -4.5 | 2.9 | 610 | 8.2 | 4-Pin | 25-35 |
| 1G4 | 1.4/.05 | -6.0 | 2.3 | 825 | 8.8 | Octal | 10-12 |
| 30 | 2.0/.06 | -4.5 | 2.5 | 850 | 9.3 | 4-Pin | 16-20 |
| 1LE3 | 1.4/.05 | -3.0 | 1.3 | 760 | 14.5 | Loctal | 4-5 |
| 1Q5 | 1.4/.10 | -4.5 | 5.8* | 1075* | 7.8* | Octal | 3-4 |
| 1A5 | 1.4/.05 | -4.5 | 5.6* | 1070* | 8.0* | Octal | 3-4 |
| 1LA4 | 1.4/.05 | -4.5 | 5.5* | 1065* | 8.1* | Loctal | 4-6 |

* Triode-connected (screen tied to plate)
All values with Ep = 90V

The first four tubes are shown for comparison purposes only. Types 1G4, 30 and 864 are not good candidates due to their high cost. The last three turned out to be good possibilities. Characteristics of the triode-connected 1Q5, 1A5 and 1LA4 are not listed in tube manuals and had to be measured. The 1Q5 is a beam power tube and the 1A5 a power pentode. The 1LA4 is a 1A5 with a Loctal base. The characteristics of the other tubes were taken from the tube manual.

RCA recommends that the Radiola III-A be operated with 22.5V on the detector and 90V with -4.5V bias on the three amplifier tubes. Accordingly, the transfer characteristics of the WD-11, 864 and the possible substitutes were examined at Ep = 90V.

Fig. 1 shows the results. The WD-11, 1Q5 and 1A5 have long, linear transfer curves. The 864 and 1LE3 have a much narrower operating range. The steeper slope of the 1Q5 and 1A5/1LA4 reflect their higher transconductance. All the tubes have similar amplification factors (µ) except for the 1LE3 which is nearly twice that of the others.

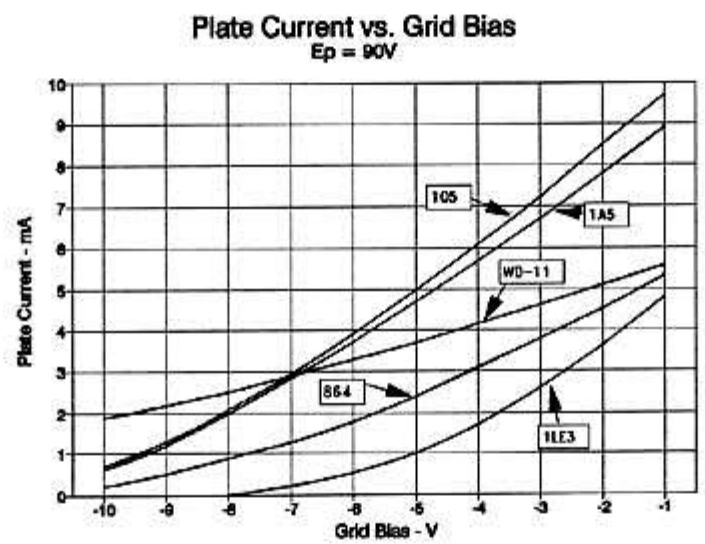

Fig. 1. Transfer characteristics of the WD-11, 864, and possible substitutes.

**Making a WD-11 Base Template**

Because of the unique WD-11 base, substitutes must either be re-based or provided with adapters. Re-basing yields good looking results, but when it's time to replace the tube, you have to do everything all over again. Adapters are easier to make and use and involve less risk to the tubes. When the tube is worn out, just plug in a new one. There are some adapters sold commercially, but they are expensive.

You can make your own adapters at very little cost using old 4- or 5-pin bases from dud tubes. These should be the small, 1-1/8" diameter bases. It is easier to drill new holes in 4-pin bases, but 5-pin bases can also be used. A template will simplify your work.

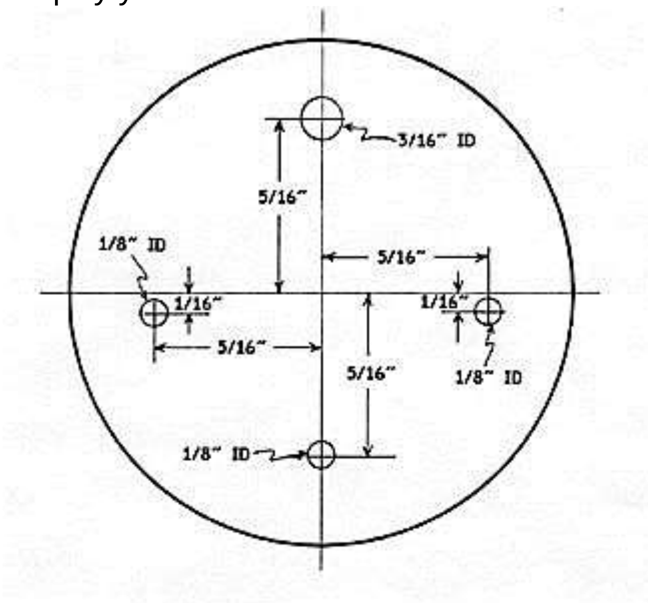


Fig. 2. Layout of drilling template for WD-11 base.

The WD-11 pin layout is shown in Fig. 2. The template was made from a scrap of 1/4" thick Plexiglas about 2" square from the local glass shop and a similar piece of Bakelite from an old radio panel. Lay out the pin locations on the Plexiglas as shown. Use a sharp scribe and be accurate. Drill one 3/16" hole and three 1/8" holes where indicated. If you spot the holes first with a center drill, the main drill will run true. A drill press is essential for precision. Also drill a 1/8" hole at the center of the pin circle for later use.

Now, clamp the Plexiglas and Bakelite pieces together and drill two holes near opposite corners for bolts to hold the two parts together. Bolt the parts together and, using the center hole as a guide, drill through the Bakelite with the 1/8" drill.

This hole in the Bakelite is the pilot hole for a 1-1/8" hole saw which you will next use to make a hole in the Bakelite to fit the tube base to be adapted. This hole may need a little filing or sanding to get a snug fit. Fig. 3 shows the template and Bakelite bolted together.

**Making a WD-11 Base**

Remove each of the existing pins on your tube base by holding it with pliers so it can't rotate and drilling away the flange from the inside. When the flange is removed, the pin will pull out easily. Use a drill of the correct diameter to remove the flange without removing any Bakelite. Scrape all the old cement out of the base. Insert the base into the template so the bottom is against the Plexiglas. You can now easily see how to position the base so that the new holes will lie between the old

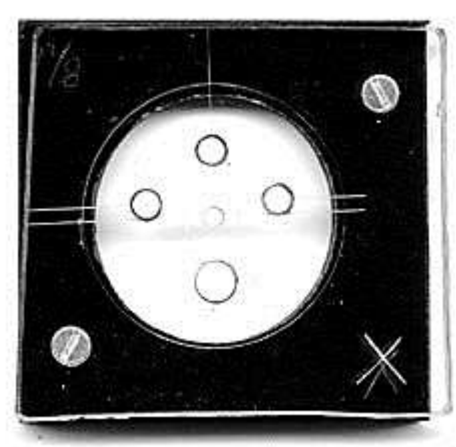

Fig. 3. Completed template assembly with Plexiglas and Bakelite pieces bolted together.

holes.
Drill a 3/16" hole in the base using the hole in the template to guide it. Insert a small piece of 3/16" rod through both template and base to prevent slippage and drill the three 1/8" holes and one 3/16" hole. The new pins are made from thin-wall brass tubing in 3/16" and 1/8" diameters from a hobby shop. This tubing is full diameter, while the holes will be slightly undersize, therefore the new pins will fit tightly and need no anchoring.
Cut the tubing to 1-3/4" length. I use a miniature tubing cutter from the hardware store. It gives a rolled edge at the cut which makes insertion and soldering easy. The best way to insert the pins in the base is to chuck them in your drill press and use the press to push them in. Make two 9/16-long collars to use as depth gauges. Drill one to slip over the 3/16" pin and one to slip over the 1/8" pins. I made these from tubular spacers.
Start the brass tubing into the base by lightly tapping it with a small hammer. Then slip on the collar and press the tubing into the base until its end is flush with the end of the collar. Watch it closely to be sure it goes in straight. Now your pin will protrude the correct distance from the base.

**Fabricating Adapters**

The sockets I used to make adapters for the substitute tubes came from the junk box. They were the molded Bakelite kind with molded-in mounting plates. The diameter below the plate is about one inch so they fit snugly into the bases with just a little filing. Cut off the mounting ears with tin snips, but leave the rest of the mounting plate in place. Wiring of the adapter will depend on the type of tube you are using as a substitute. Diagrams for the 1LA4/1LE3 and 1A5/1Q5 are shown in Fig. 4. The resistor across the filament connections needs explanation.

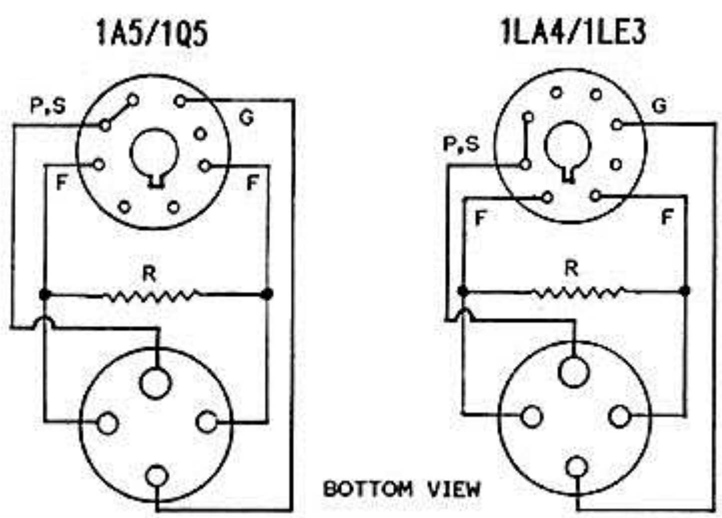

Fig. 4. Wiring diagrams for adapters. See text for function of resistor "R."

Volume in these old sets is controlled by varying the filament voltage through a rheostat. It is sized for use with 0.25A tubes. Because the substitutes draw only 0.05 to 0.1A, the rheostat will have little effect on filament voltage and the set will run wide open with no volume control action.

For substitutes to behave like WD-11s, they must draw similar filament currents. The 1/4-watt resistor, R, shunting the filament increases the total circuit current to about that of a WD-11. This will give good volume control action. R should be 6.8 ohm for the 1Q5 and 5.1 ohm for all other tubes.

Connect the resistor between the filament lugs on the socket and solder wires to them and to the grid and plate lugs. The wires can be bare except the one from the plate (or grid depending on how you orient the socket with respect to the base). This wire needs to be insulated where it crosses over the socket. Guide the wires through the pins in your WD-11 base, seat the socket firmly in the base and solder the wires to the pins.

Drill two small holes on opposite sides of the base into the edge of the socket. Make sure that the holes go between socket pins. The diameter of the hole will depend on the size of the self-tapping screws you use to fasten the socket to the base. It is a good idea to experiment on some scrap Bakelite before drilling the sockets.

I use #0 x 1/4" or #1 x 1/4" screws. Using a larger drill, enlarge the hole in the base shell so that the screw passes freely. Do not drill into the hole in the socket edge. Insert the screws to hold the base and socket together. Don't over tighten them or you may crack the shell.

Fig. 5 shows (A) a WD-11 tube, (B) a re-based 864, (C) a 1LE3 in its adapter, and (D) a 1A5 in its adapter. The superficial resemblance of the substitutes to the WD-11 is obvious. Details of the adapter construction are also visible.

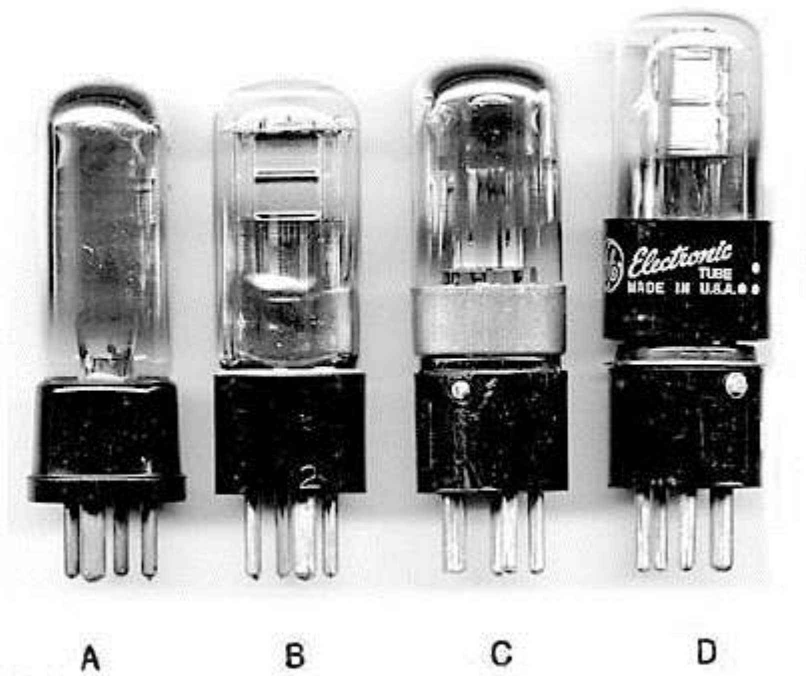

Fig. 5. From left: WD-11 tube; re-based 864; 1LE3 in its adapter; 1A5 in its adapter.

**Testing the Substitutes**

A Radiola III-A was equipped with WD-11 tubes and its operation studied. This set has 2 sections: a regenerative detector and an AF amplifier followed by a push-pull second audio output stage. There is provision for headphones after the first audio stage and each section has its own filament rheostat.

Because of the various interacting adjustments to be made for proper reception, there could be no "standard" setting for comparing tubes. so the test was subjective. In each case, a weak station was tuned in and the positions of the filament and regeneration controls noted at the settings for loudest volume and best sound quality. The position of the regeneration control at which oscillation occurred was also noted.

The set was operated with 22.5V on the detector and 90V on the audio amplifiers with -4.5V bias. The filament supply was 1.5V. A voltmeter was connected across the filament pins so as not to exceed 1.1V for the WD-11s. At first, only the "front" half of the set was operated (detector + first audio) with headphones.

Using WD-11s, the set was adjusted for best volume and sound. Then the WD-11s were replaced first with 1LE3s, then with 1A5s, and the set re-adjusted for optimum reception in each case. You'll recall that the 1LA4 is electronically identical with the 1A5.

The 1LE3s were rather touchy. Oscillation onset occurred at a much lower setting of the regeneration control and the filament control had to be reduced to avoid distortion. Nevertheless, performance was satisfactory and quality was acceptable. The volume was louder because of the higher $\mu$ of the 1LE3.

The 1A5s also oscillated at a lower setting than WD-11s and required reduction of the filament voltage, but overall performance was much smoother than the 1LE3 and distortion was less at high volume.

A horn speaker was then connected to the second push-pull audio stage and the filament rheostat turned on. There was a noticeable tendency for the 1LE3s to distort at high volume levels, but satisfactory room-level sound could be achieved with filament adjustment. As before, the 1A5s were smoother and more like WD-11s in operation. Distortion was less; room-level sound was easily achieved. In all cases, volume control action was as good as with WD-11s.

After similar tests were done with 1Q5s, it was found that there was little perceptible difference in the performance of 1A5s, 1Q5s and 1LA4s. In conclusion, I prefer the 1A5 or 1Q5 for a substitute. They are cheap and available and perform very much like the WD-11. The 1LA4 works just as well, but is a bit more expensive. If you happen to have some 1LE3s on hand, however, they are also functional and will do the job.

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