Life and failures of selenium rectifiers

Too often, when powering an old radio or an electronic set that uses selenium rectifiers in its power supply section, these components fail. Symptoms are a quite fast overheating of the rectifiers themselves, a considerable reduction of the AC and DC voltages in the set, with dimming of the light bulbs, and an overheat of the power transformer. If a fuse is present in the primary circuit, usually it blows. If the fuse is replaced with one of greater current capacity, the power transformer can burn.

Many improvised technicians concluded that selenium rectifiers degrade in the years, their life being quite limited, and then they have to be anyway replaced. According to what can be read in some sites, the direct voltage drop increase with age and this causes overheating. Nothing further from the truth! Should the DC voltage drop which can be observed in case of defective rectifier be caused by increased forward resistance, its effects on overheating should be less noticeable and the power transformer should even run cooler. If we assume 50 V drop across a 220 V bridge operating at 100 mA, this drop should result in about 4 W power dissipation increase. Actually, in case of rectifier failure, both the rectifier itself and the power transformer become hot and other secondary voltages are significantly low. Then the failure mechanism must be quite different.

Selenium rectifiers were rated for almost infinite continuous service life, over than 60.000 hours, according to this **1951 GE ad**. In comparison high-rel vacuum tubes had life expectancies between 5.000 and 10.000 hours. Failures in selenium rectifiers are therefore unrelated with their age. In the collection there are many old radios and electronic sets still working fine with their 65-year old original components.

Selenium rectifiers are made depositing a tin layer of selenium between a steel or aluminum plate and a counter electrode, sometimes spring-loaded. Reverse voltage rating of each cell may vary from 18 to about 30 volts, depending upon the type. Forward drop is about 1 volt per cell. Manufacturers offer high-voltage rectifiers, up to 100 kV, series connecting enough cells to withstand the required reverse voltage. Rectified current rating is in the order of 0.35 amp per square inch or even higher when forced-air or oil cooling is used. From the typical curves below, we see that the typical reverse current is fairly high, about one hundredth of the direct current.

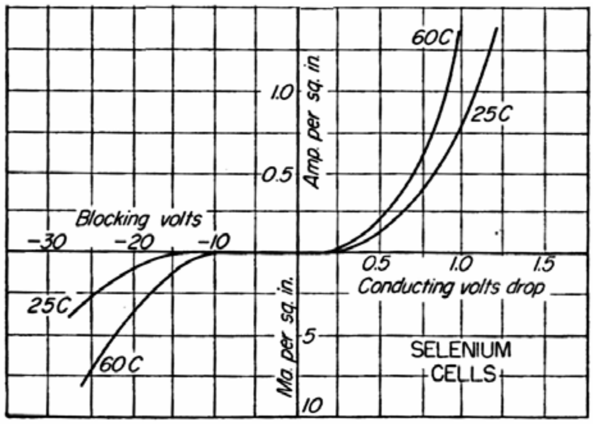

Fig. 1 - Typical curves of forward and reverse current-to-voltage characteristics at different temperatures.

Selenium cells may be subjected to some aging in the first year of operating or idle life, with subsequent increase of forward and reverse resistance. Increase, if any, is not greater than 7 % of the initial value. Therefore we can assume a forward drop well under 1.2 volts per cell. Now let us consider the typical application of a bridge rectifier in the power supply section of a German radio. We can assume an input voltage of 220 volts RMS and a DC current say of 120 mA. Five to six series-connected cells are required for each arm of the Graetz bridge, giving a total forward voltage drop not exceeding 15 volts. At 120 mA the total power to dissipate in the bridge will be under a couple of watts, definitely too low to cause overheating and failures as stated by those people who hastily replace selenium rectifiers just because they are too old to work.

Selenium rectifiers are reliable, nevertheless sometimes they fail: why? There are two possible reasons. The first one is an oxidation and a subsequent corrosion of the metal plates, steel or aluminum, due to improper storage. Anyway in this case all the components and even the same chassis should be more or less visibly corroded. The second and by far the more common reason is in improper handling of the set at its waking up after a long idle period. In this case damages are made by people who rashly powers that old radio found in the basement of the grandma house just to see if it can be sold on ebay as working.

Looking at the curves of fig. 1 we see that for a reverse voltage of about 25 volts per cell the typical leakage current is between 2.5 and 7.5 mA, depending upon the temperature. In selenium rectifiers leakage currents, as it happens even in electrolytic capacitors, increase with the stand-by or storage time. When they are idle for years, reverse leakage current become higher and higher. Let us assume that after a prolonged storage a reverse current of 50 mA flows at the power-on. This current adds 11 W extra power dissipation in the rectifier which causes a fast temperature rise up, a further increase of leakage current, up to the complete burnout of the rectifier. The abnormal leakage also overload the same power transformer, causing overheating and burnout.

Leakage currents can be readily returned to their normal values with a low voltage reforming, even recommended for electrolytic capacitors. It can be performed powering on the set at one half of nominal supply voltage for ten to fifteen minutes. A Variac is the best tool, to slowly raise the primary voltage while monitoring the power drain. As alternative, a step-down transformer or even a series connected resistor or a lamp can be used to limit the supply voltage during the reforming. The reforming process must also be performed each time an already restored radio was left idle for several months or even years.

What can be done if the selenium rectifier is defective and must be replaced? In this case we can try to repair the old rectifier using silicon diodes, as in this **example**. Otherwise we can use a silicon bridge, preferably a type with a mounting hole that can be screwed or riveted to the chassis. Use of silicon replacements will cause a little DC voltage increase, due to the fewer forward junction drops. If the voltage is to be returned to its nominal value, the best solution in the insertion of a power resistor between the positive terminal of the silicon bridge and the positive terminal of the filter capacitor. A zener diode can also be used, provided that it is selected for the proper power dissipation.

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