Homemade nixie tubes

As you may have read, I have tried to make nixie and other tubes in a simple home laboratory. It may seem to be crazy and impossible but I try. The writers in all available books have said: "Making homemade tubes is impossible." I believed them for a long time, but I wanted to try. Now it's the first anniversary of my “Private Tube Manufacture ”. One year of big failures and small successes.

I want to tell you about one success, preparing nixie tube type LC1D.

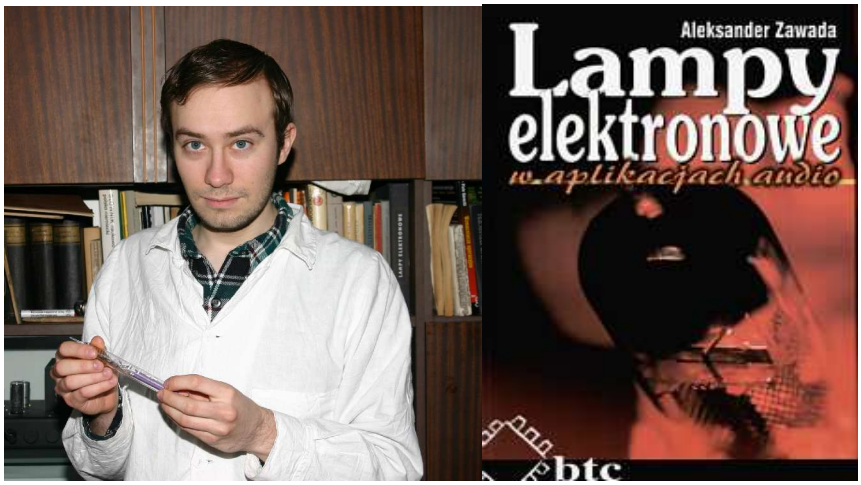


fig. 1. Author and his book "Tubes In Audio Applications ”, printed in 2004.

Briefly about nixies

The nixie tube is a gas discharge tube, where the cathodes are digits, symbols etc. The anode is usually a metal grid. (Despite the use of words "anode" and "cathode" it is not a diode. The cathode is connected to the negative current supply and the anode to the positive. Any electrode element can be the anode or cathode, with some reservations.)

The material of electrodes is steel. In 1963, professor Wieslaw Barwicz [1] tried to use an alloy called “constantan ”.
Unfortunately, it wasn't a good idea, because the nixies had a short lifetime. The sputtering of metal was very strong. That's why professor Barwicz started to use stainless steel “OH18N9 Baildon ” (non –carbon, 18%Cr, 9%Ni). Producing the aesthetic shape of digits or symbols can be done using photolithographic etching methods – similar to how printed circuit boards are made. That's why the symbols in normal nixies look so nice. In normal nixies the electrodes are isolated by alumina ceramic (aluminium oxide Al_2O_3) or in some cases mica.

The supply wires are copper, embedded in a glass disk or wafer. Thus far isn't possible to fuse the glass wafer to the glass bulb in my laboratory, even having factory-made glass wafer – f ig. 2. It's not possible, because it's necessary to have pure nitrogen or argon and graphite pieces.

fig. 2. Factory glass wafer (8 pin for octal tubes)

That's why I use glass wafers prepared myself- fig.4. The biggest problem is fusing the glass wafers to the glass bulbs, but fortunately it's possible.

Optimal composition of working gases for nixies is ca. 99 to 99.9% neon and 1 to 0.1% argon (according to Barwicz). Small amount of argon lowers the discharge voltage.

Optimum pressure for nixies is ca. 30 Torr (it's 1/25 of normal atmospheric pressure), but it depends on distance between cathodes and anode. Too high pressure isn't good, because discharge voltage rapidly increases (and current too). Too low pressure isn't good, either. In effect the discharge voltage gets higher and higher, while discharge current drops. Also sputtering has to be considered, because of high ion energy due to higher mean free path of ions in lower pressure. Sputtering can contribute to a far shorter lifetime. Moreover, under such conditions glowing is large and diffused.

There are Paschen's curves, which describe the discharge voltage in relation to the product of pressure and distance between electrodes (p*d) for a known composition of gases - fig. 3. It is possible to find such a value of p*d for which the discharge voltage reaches minimum. However, optimum value of p*d in nixies is lower. In effect the discharge between supply wires is not possible while is possible for symbols or digits.

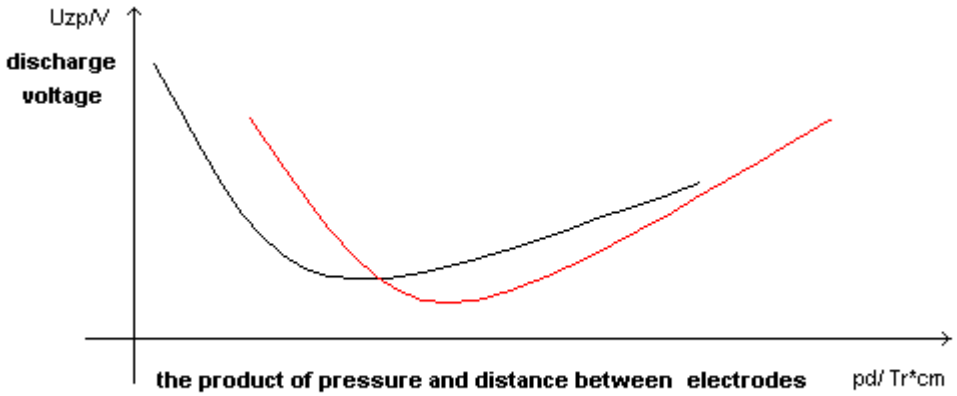


Fig.3. The Paschen's curves. Black curve for pure neon, red curve for 99% neon and 1 % argon

LC1D nixie …

My nixie is very poor compared to a factory-produced nixie. To tell you the truth: my kitchen is very far from professional manufacture. LC1D has 3 symbols:“0 ”, “1 ” and “2 ” – please see datasheet. It's complicated to do nixie with more symbols, because metal-glass seals are very hard to make (vacuum-tight connector!). I can do similar vacuum-tight connector as in light bulbs, but with four supply wires -fig. 4.

fig.4. glass-metal connector with for wires

Believe me, it's very complicated. Very often the seal breaks during cooling. The bottom part of the connector glass is widened. Such a shape is necessary to fuse connection with glass bulb. It's easy to make a mistake during this connection.

I can't use a photolithographic method in preparing electrodes. Instead I use zinc coated steel wires. Then I dissolve the zinc plating in nitric acid, followed by cleaning in water to remove all acid and residue. Dry wires are formed to make symbols and “snake-anode ”- fig. 5.

fig.5. The electrodes

The next step is connecting the digits to form a stack using a glass droplet – fig. 6. In normal nixies it's realised using preformed ceramic alumina. The glass isolation is necessary to prevent glowing on the wire leads where they approach the seal.

fig.6. The pocket of electrodes

For the glass bulbs I used glass soda pipe (17 mm outer diameter). I told you earlier, that fusing the glass bulb with the wafer is very hard. I tried to do eight nixies, but only one was successful.

It's very important to have a good vacuum inside the nixie before filling it with working gas. It's recommended to have at least 10^{-4} Torr. In January 2006 I had only a rotary pump which gives 10^{-2} Torr. Actually I have high vacuum of 10^{-6} Torr or better due to use of oil diffusion pump. If the vacuum is good enough then we fill the gas.

It’s possible to use pure neon or neon and argon mixture. I have pure neon, that's why my nixie started when voltage was ca. 430V. Truthfully, it

is because my vacuum was poor when I used a rotary pump. I really had an air-neon mixture.

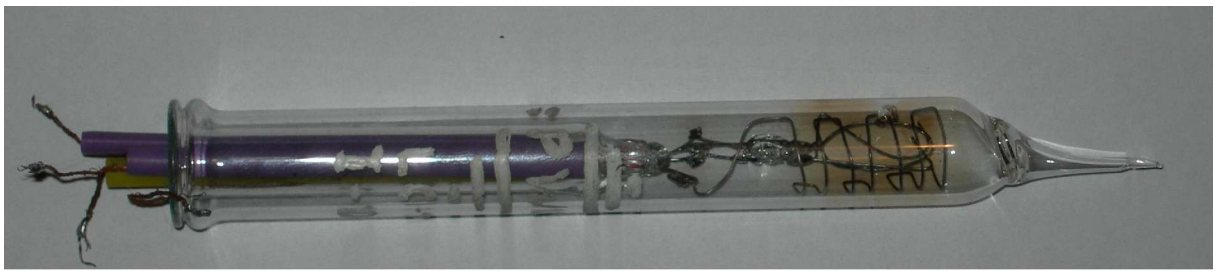
After 600 hours operating time my nixie fires when voltage is around 280V or even less. It's possible because sputtering of the electrode material may absorb some gases (oxygen, nitrogen).

During the experiments I lost a lot of neon because I tried different working pressures to get low discharge voltage and a nice glow. Because neon gas mixture is very expensive (ca $100 for 2 litter, 700 Torr bottle – this makes 1400 Torr*liter of 25%Ar 75%Ne mixture)

Fig.7. The glass bottle of neon

I had to stop experiments in order to save some remaining pure neon. To start next experiments I will look for better valves.

The nixie worked 700 hours and is still working! You can see some degree of sputtering (brown glass), but it isn't a very big problem – fig. 8.



I forgot tell you that I tried making easier tubes - fig. 9.

Fig. 9. Other tubes produced by Private Tubes Manufacture.

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