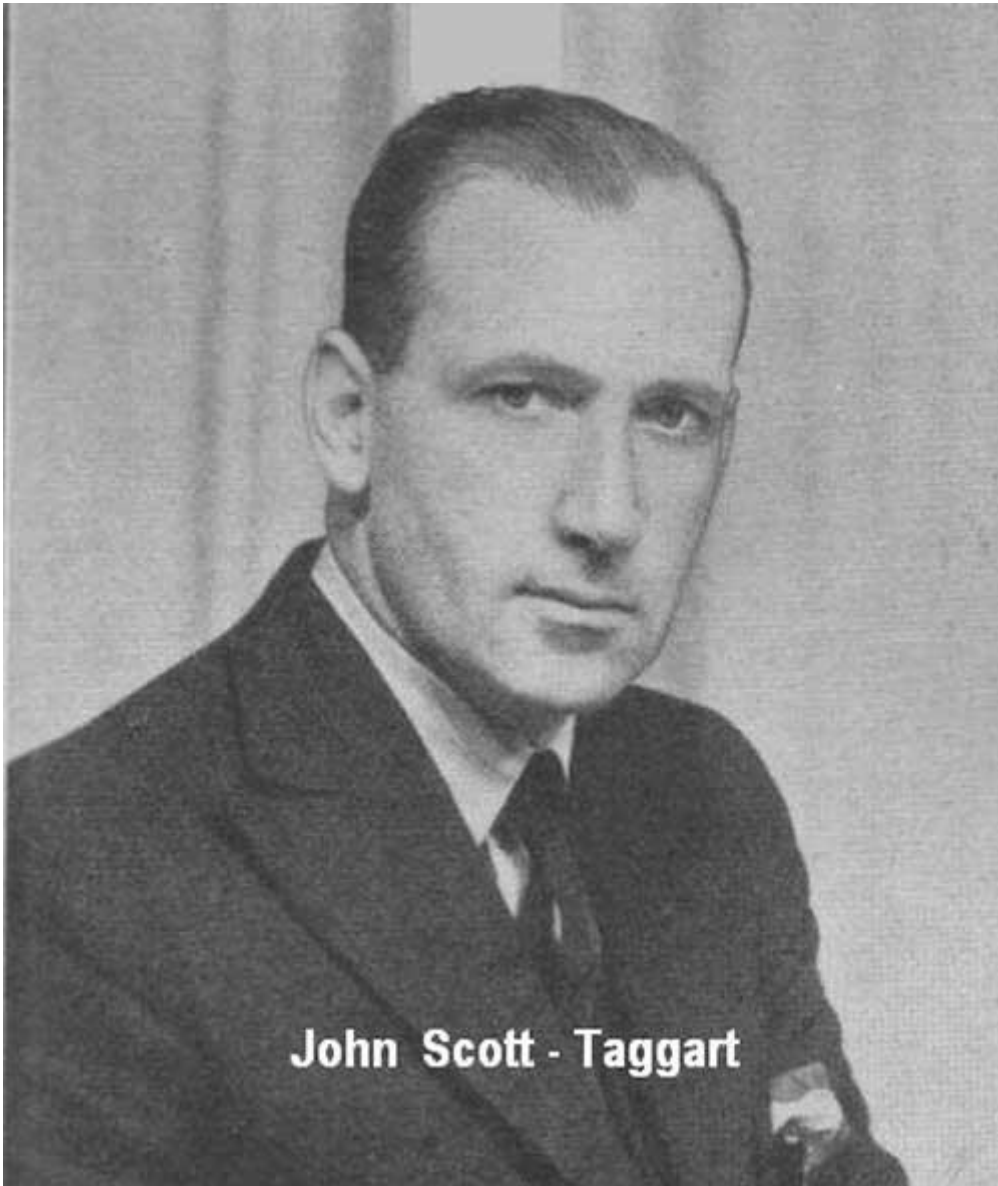


The NEGATRON by John Scott-Taggart

by Wolfgang Holtmann



The Briton John Scott-Taggart had invented a triode in 1919 with an additional anode, which is able to produce oscillations by a "falling characteristic". He wanted to bypass the existing patents of Lee de Forest, Meissner, Armstrong and Huth-Kühn. In anticipation of granting the patent, he delayed the publication of the details until 1921.

The “Negatron :” A Negative Resistance Valve.—The present author has invented a new vacuum tube which possesses negative resistance characteristics. Its applications as an oscillator, amplifier, detector, etc., are comparable to those of the Dynatron while working on an entirely different principle. As the patents for this valve have not been published at the time of writing, it is not possible to give details in this volume.

Aus: "Thermionic Tubes" von John Scott-Taggart, 1919

The whole thing was, however, a tube-historically, mayfly. That is why you will find this tube type today only a few collectors in the showcase. Udo Radtke has a photo of it on his homepage. This copy was made in about 1923 by Mullard and by the company "Radio Communication Co." (RCC) under the brand name "Polar". Tyne also mentions a similar tube - Japanese origin type TWW.



A little personal history, or how it came about.

*At the last Stammtisch in Mühlheim (organized by the operator of the Röhrenbude, Jochen Gittel) I learned that **Michael Pape** is in the position to make tubes!*

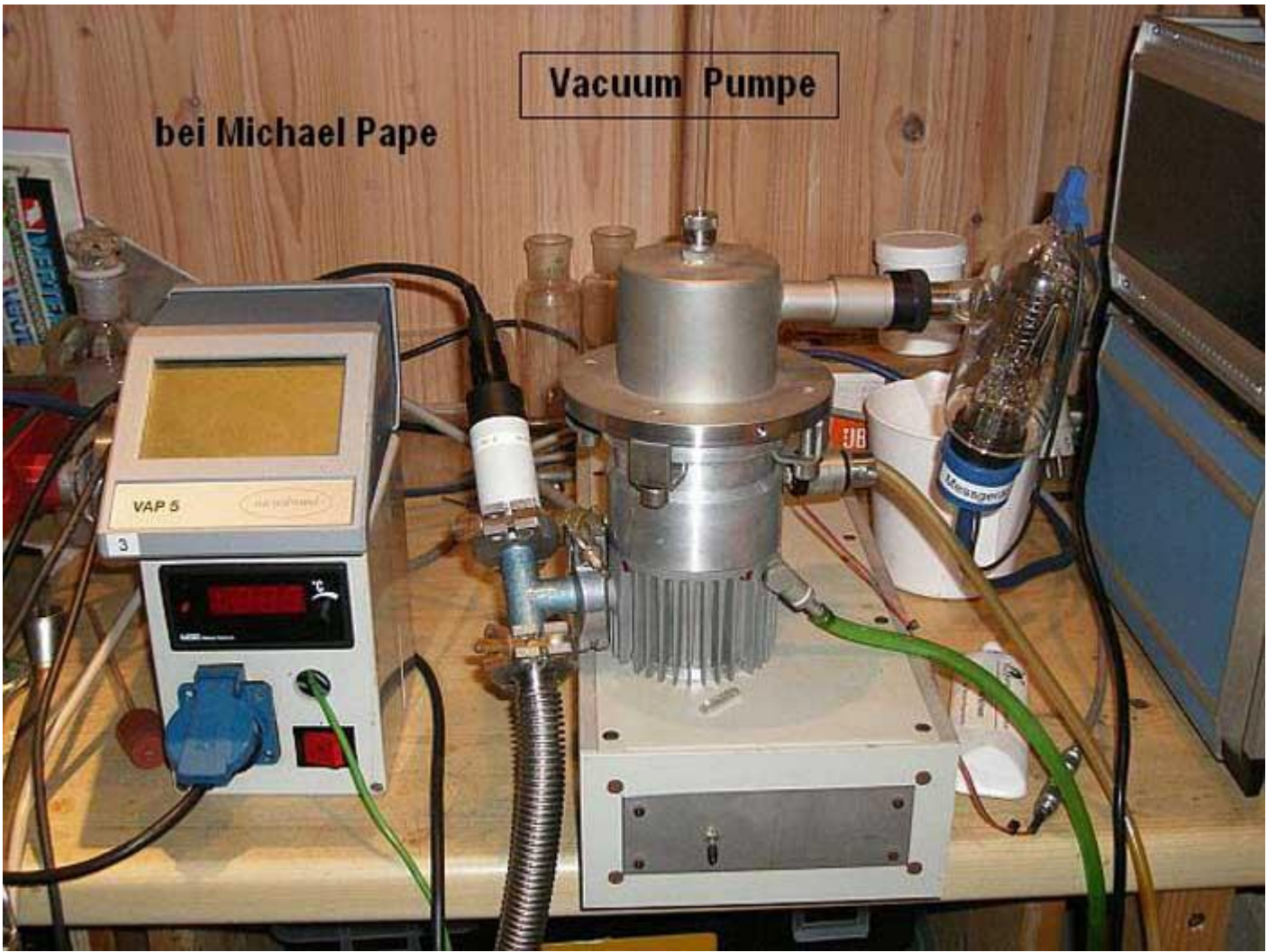


*Immediately I came up with a long cherished wish to be able to carry out experiments with a NEGATRON. Spontaneously I asked:
"Dear Michael, be so nice, can you build me such a strange tube?"*

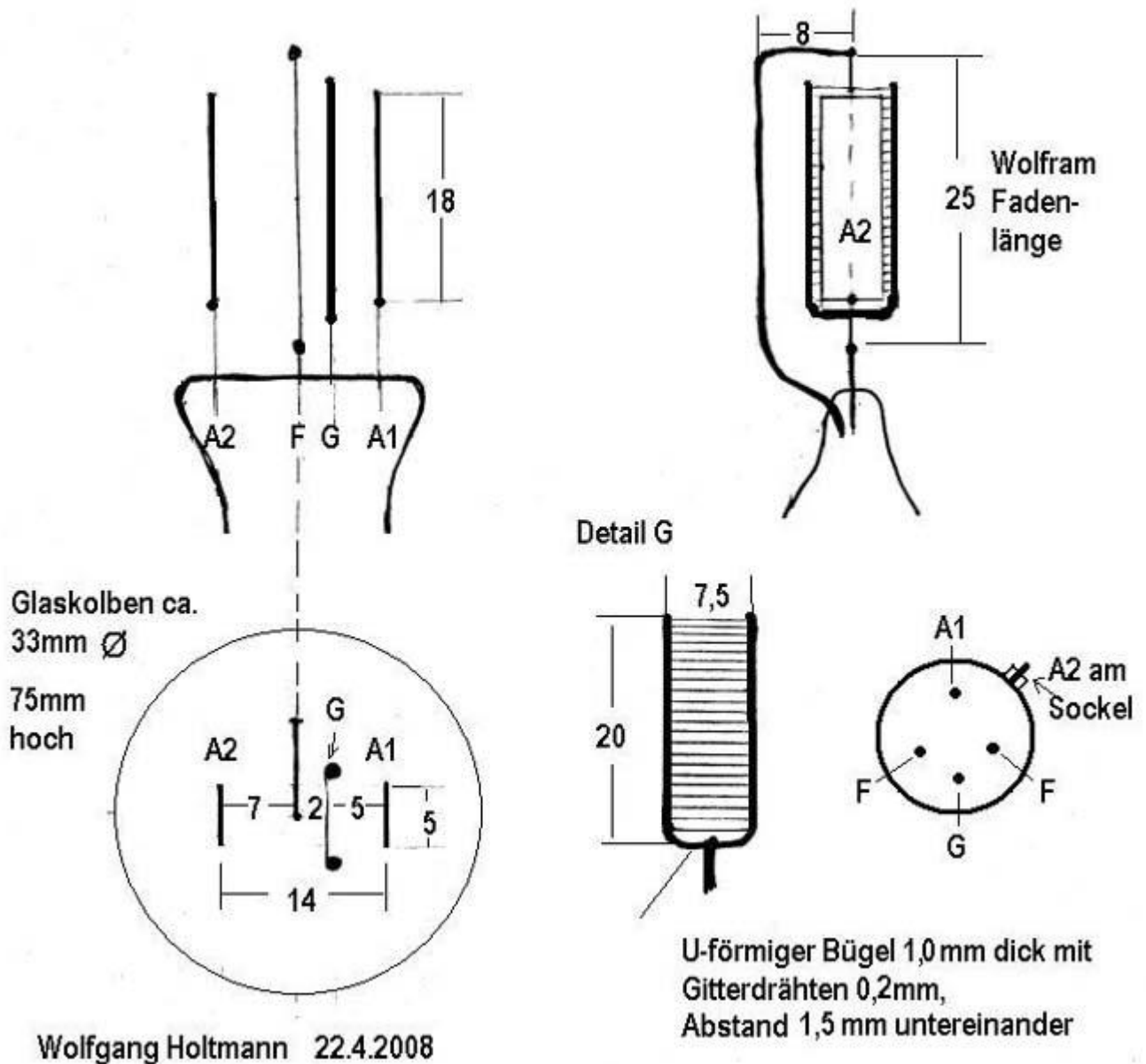
The photo of the original tube was for me a clue to make a design drawing for him. After this template, the replica shown below was created. Michael has the technical capabilities and knowledge to fabricate electron tubes with high vacuum (5×10^{-7} torr).

bei Michael Pape

Vacuum Pumpe



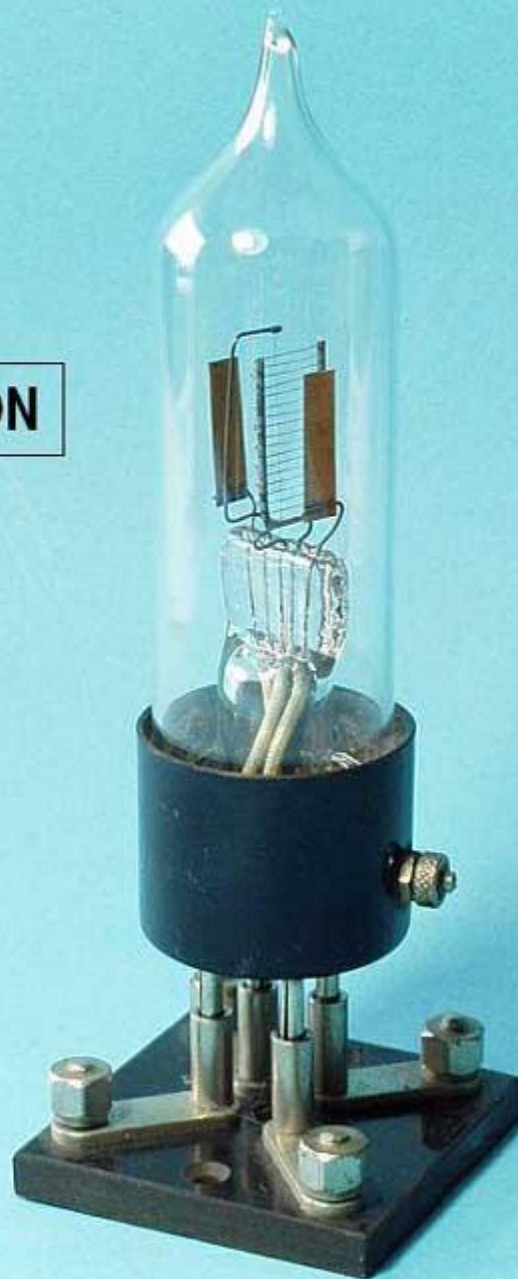
Replica of Scott-Taggart's NEGATRON



These niches in radio and tube technology have always interested me. What's so interesting about this thing? By the way, at Barkhausen and Kammerloher nothing is to be found to this tube variant. Michael Pape has succeeded in producing a functional replica. My heartfelt thanks for that!

Foto:
Wolfgang Holtmann

NEGATRON

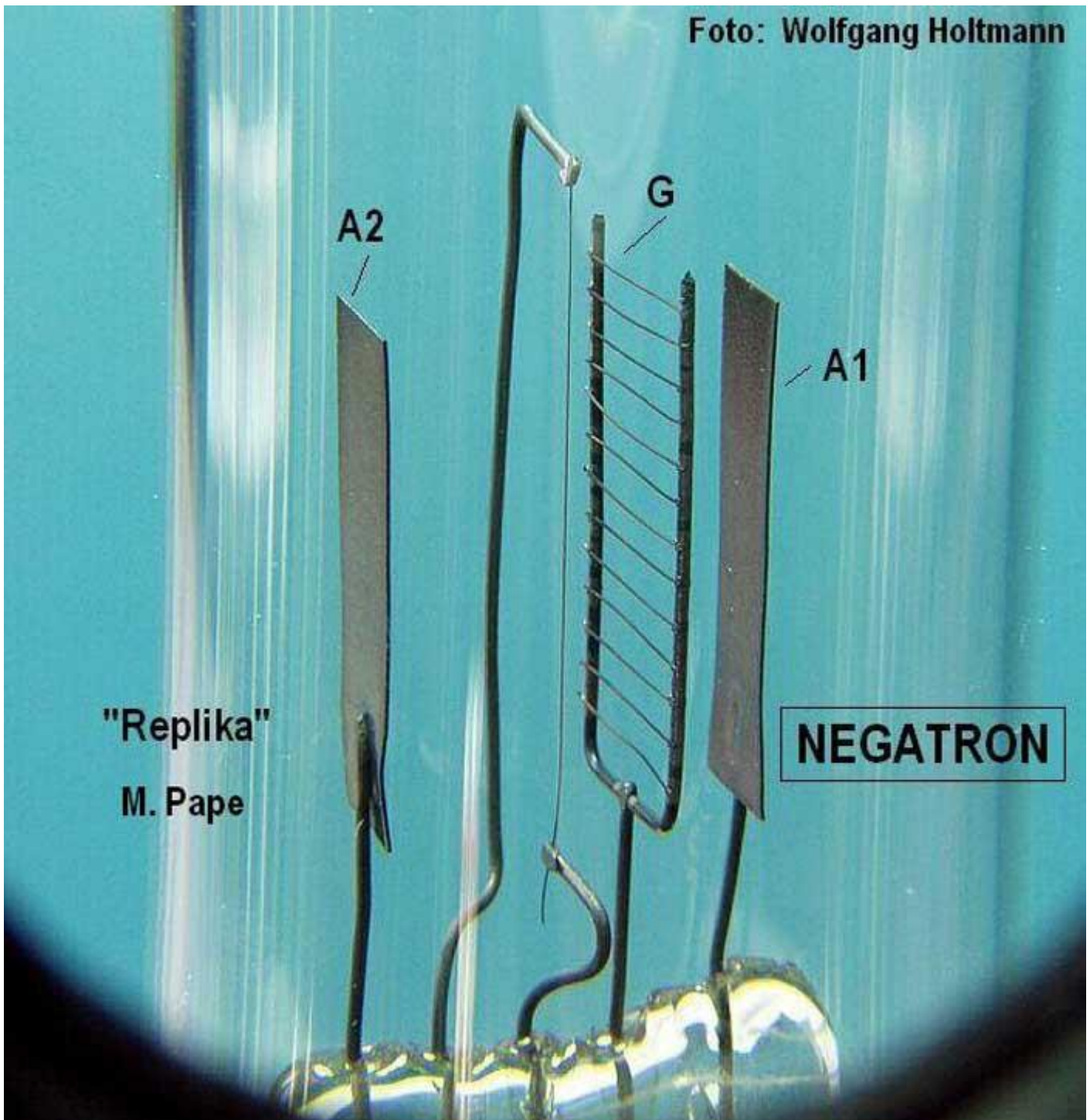


"REPLIKA" angefertigt von M. Pape, Overath

Function

description Actually, the structure of the electrodes is kept quite simple. To the right of the vertically arranged filament (tungsten) we see a triode with a U-shaped grid and the anode 1. To the left of the filament another anode 2 is installed.

Foto: Wolfgang Holtmann



Let's put a pos on both anodes. Tension, the electrons migrate to both the right and left anodes. However, if the grating is positively biased against the filament, the majority of electrons from the space charge cloud around the filament will move toward A1. This automatically reduces the anode current component to the left anode 2!

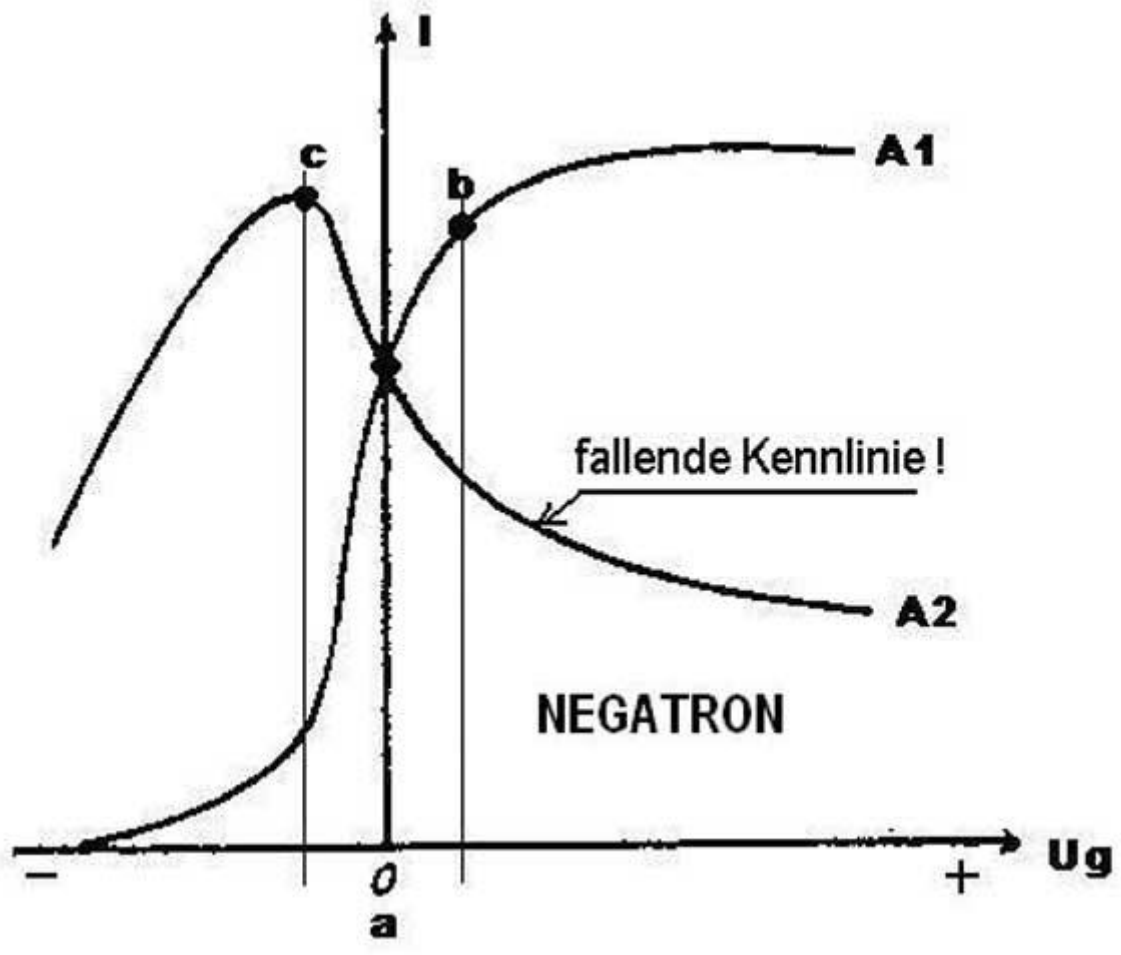
Conversely, if we make the grid negative, the anode current returns to A1 logically. Most electrons are now looking for their way to the anode 2. So it has to do with a "power distribution control" with the help of the grid. Although there is no grid between the thread and A2, it is possible to influence the I_{a2} as described!

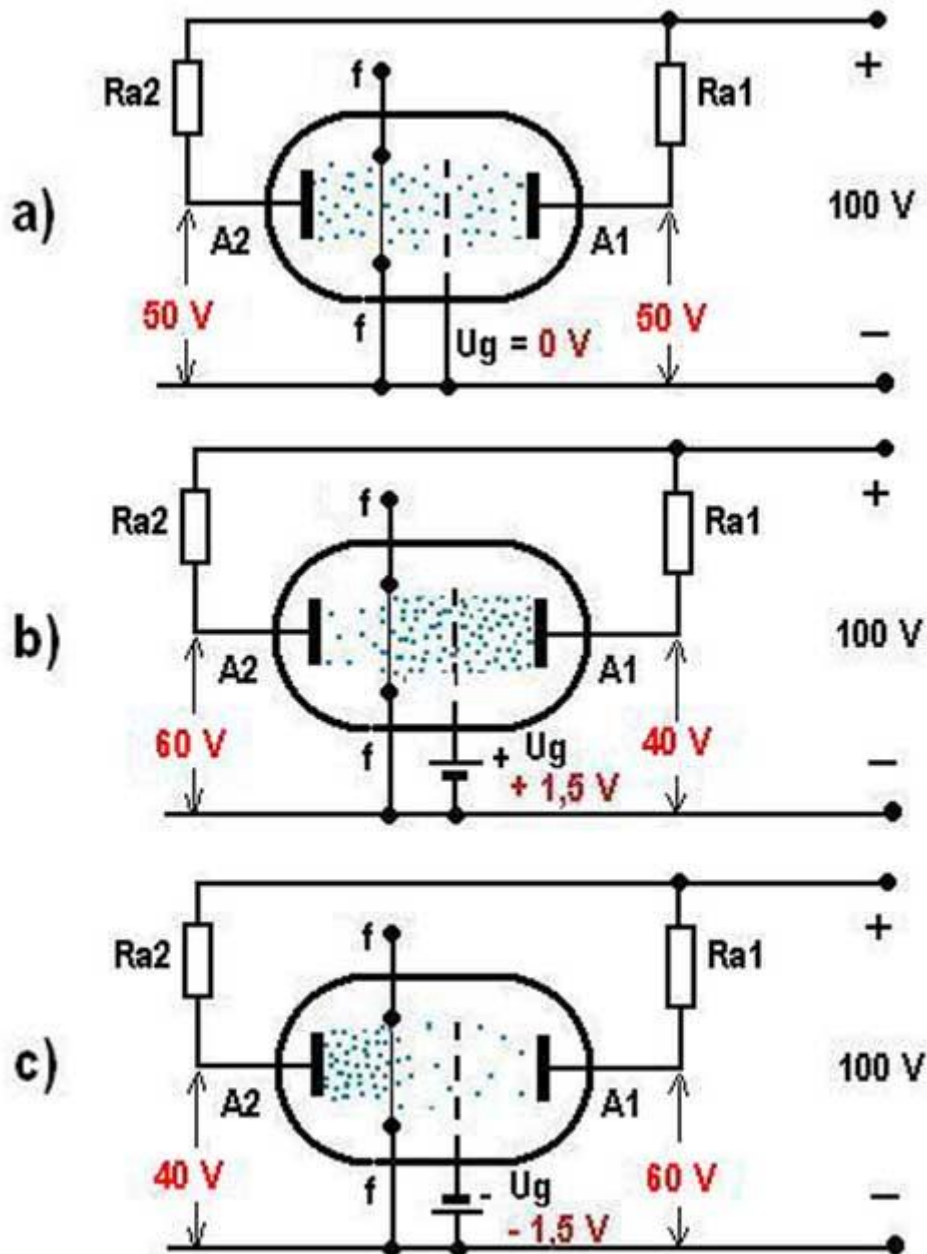
The peculiarity of this invention (or perhaps discovery) is: I_{a2} is in a certain range opposite to I_{a1} ! One speaks of a "falling I_{a2} characteristic".

Remarks:

I deliberately forego the term "negative resistance" (hence the name: NEGATRON), which says little to one or the other. The above explanation is in my opinion much clearer and more detailed!

The drawings below serve only to clarify the principle and are greatly simplified. Also, no consideration is taken to the voltage gradient along the filament.





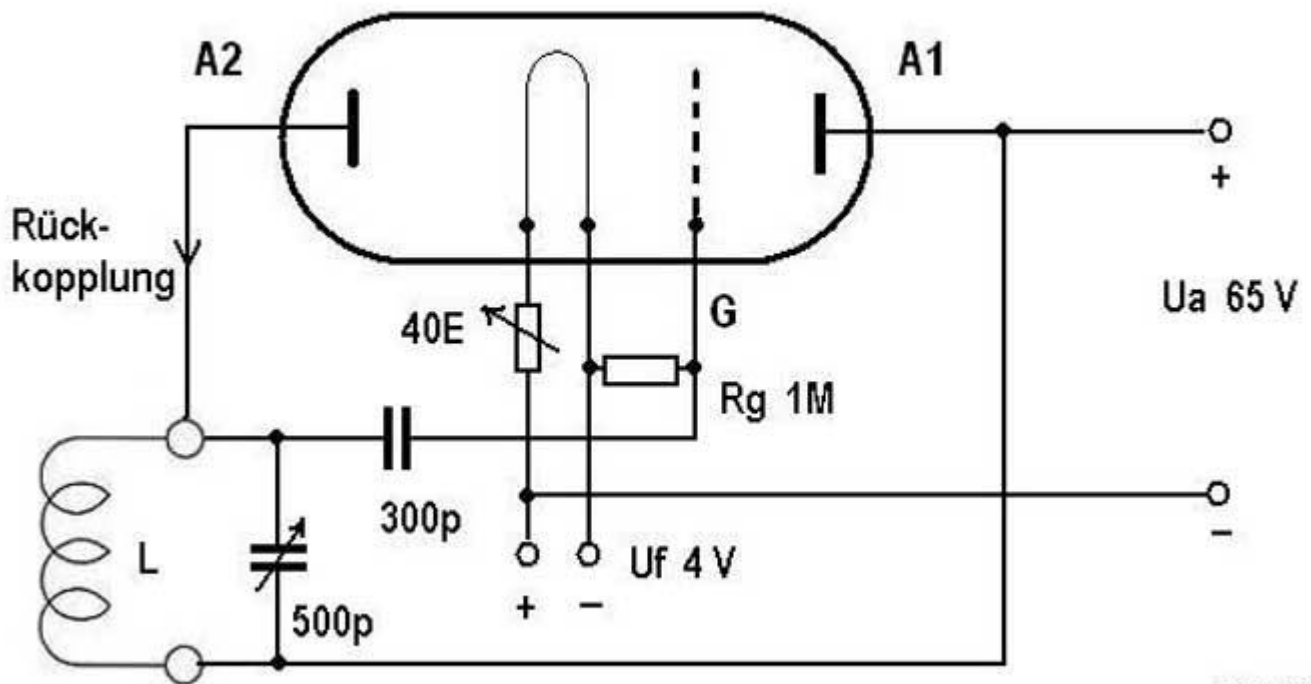
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NEGATRON

Prinzip Erklärung

In the case of a triode, it is known that a phase rotation of the anode voltage of 180° with respect to the grid voltage occurs (with a R_a and reference point the cathode). This is just as valid with the NEGATRON for A1. For A2 the conditions are reversed, as explained, ie grid voltage and the (amplified) anode voltage are in phase !!

John Scott-Taggart exploited this fact in his invention and adapted an oscillator circuit according to Meissner (= inductive feedback from the anode to the grating coil) in such a way that the separate and oppositely poled feedback coil can be omitted to eliminate the otherwise usual phase rotation. You can now connect A2 directly to the grid coil! Of course, A2 needs an anode voltage, so coil L is connected to $+U_b$. The grid capacitor does not allow it to reach the grid. Anode 1 has only one auxiliary function and is AC voltage to 0 volts potential.



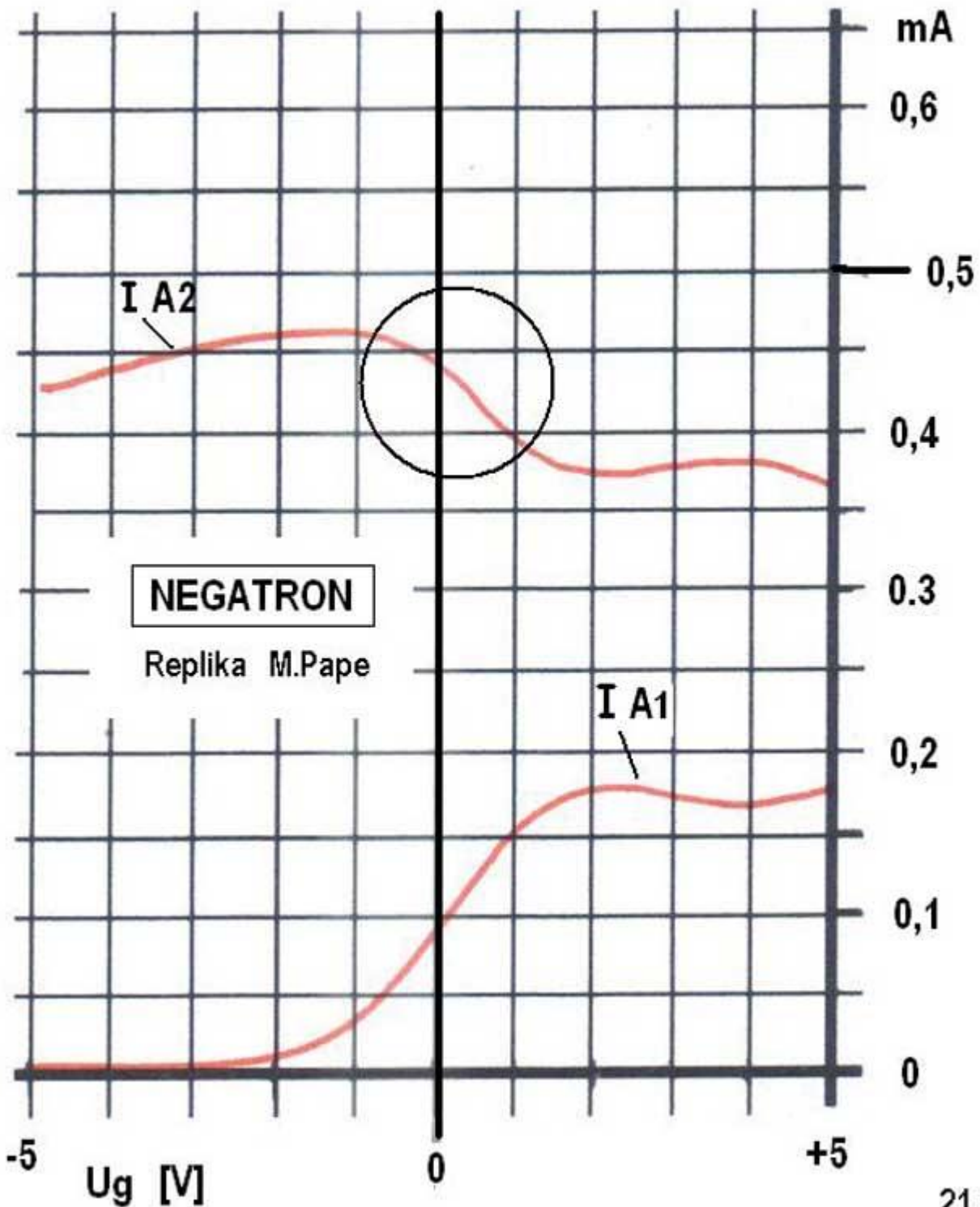
Wichtig: Spannung an A2 und G ist phasengleich !

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Characteristics of the replica

$U_a 1 + 2 = 100 \text{ V}$

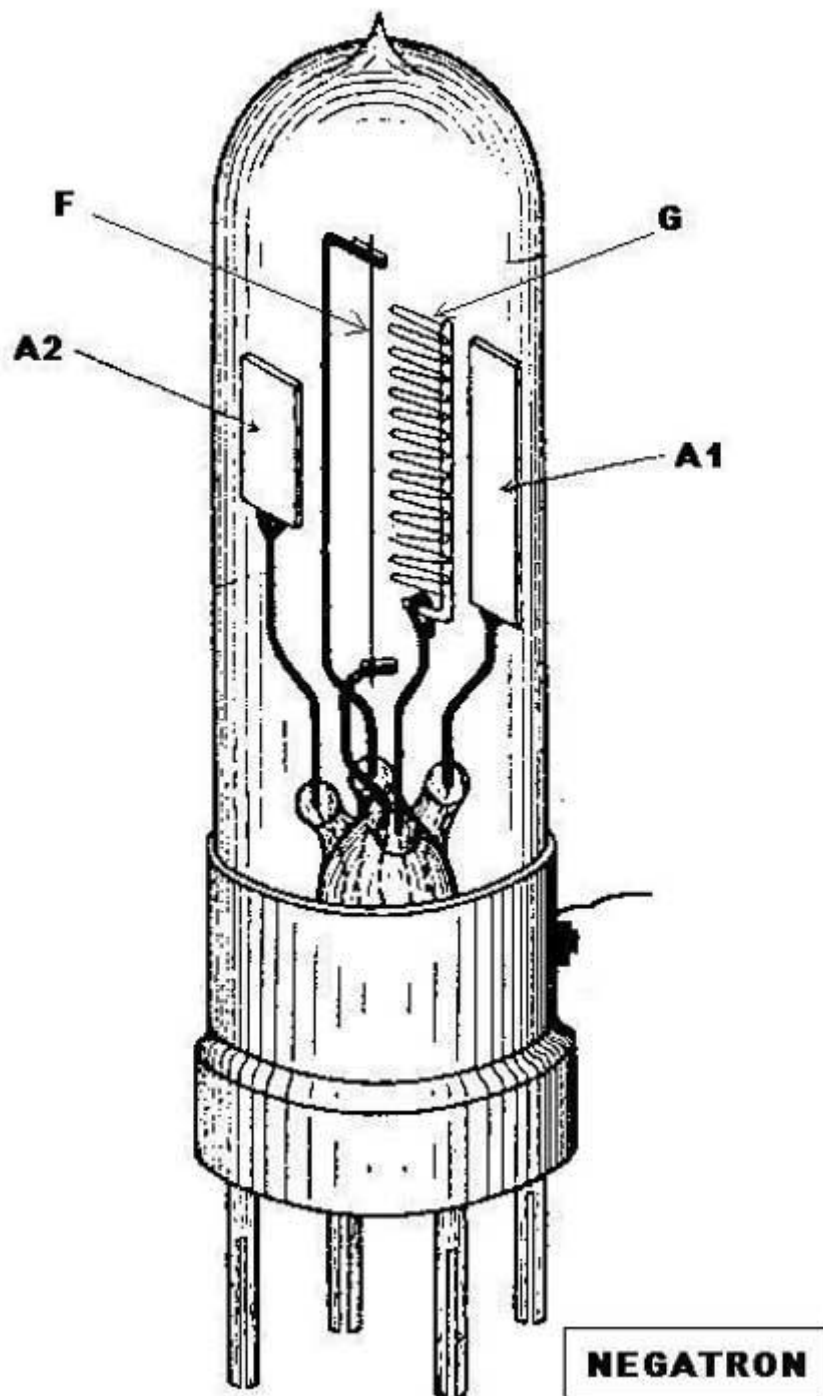
$U_f = 3,5 \text{ V}$



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I mentioned already, the dimensions of the electrodes and their distances between them, are estimated by eye! I think that explains the big difference in the anode currents. If I had made A2 only half as large from the surface, I_{A2} would have been more akin to I_{A1} . Here is an idea that can sometimes be found in the literature:



By the way:

It is noticeable that the NEGATRON discussed is very similar in function to the NEGADYN circuit developed by Numans and Roosenstein in 1923. More about it here. <http://www.jogis-roehrenbude.de/Radiobasteln/Negadyne/Negadyne.htm>

One needs only imagine the positively biased space charge grid as A2. Even with a space-charge grid tube, the filament near grid shows a "falling characteristic"! The advantage here is that this additionally accelerates the electrons towards the anode. So even an anode voltage of about 6 to 20 volts is sufficient.

Then, by coincidence, I discovered that several years before Scott-Taggart's invention, Irving Langmuir in the US experimentally made a tube with the same electrode arrangement.

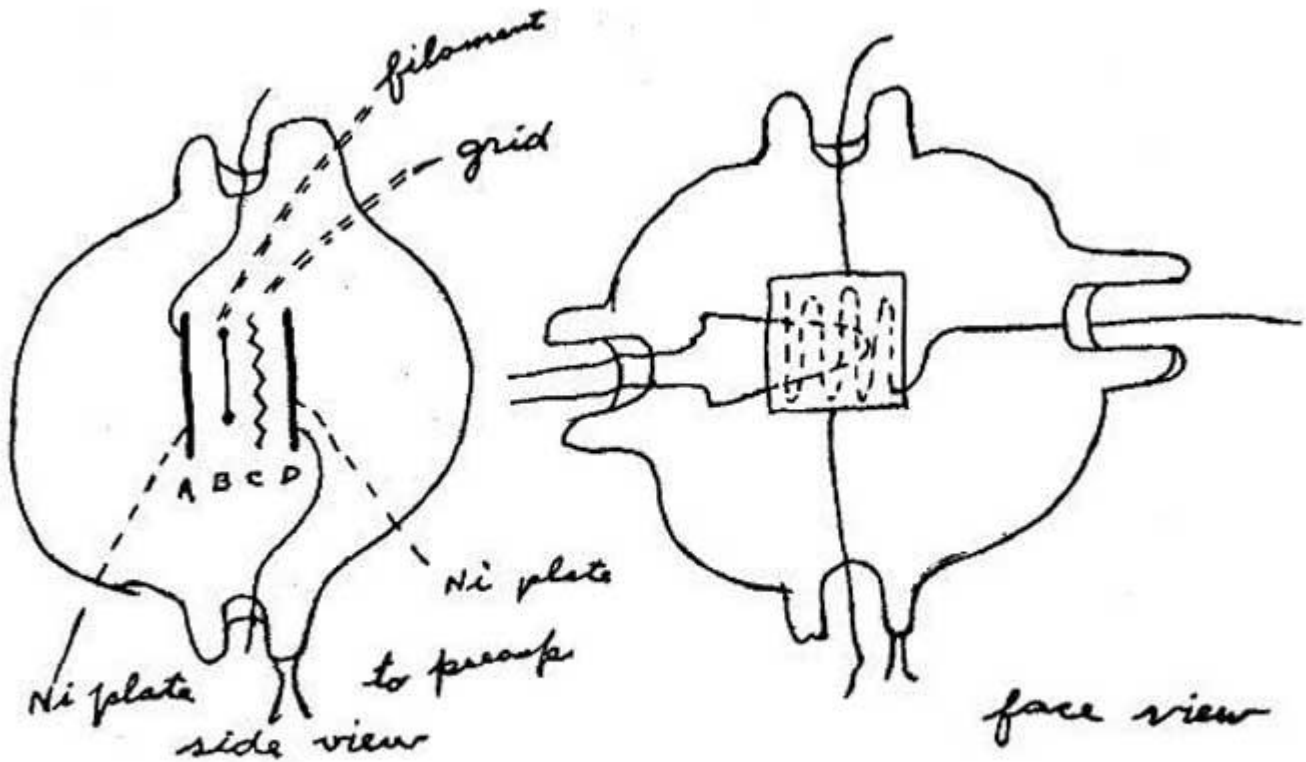


Fig. 8-1. Sketch of Langmuir's first attempt to build a high-vacuum Audion. (Reproduced from Langmuir's laboratory notebook No. 413, p. 228.)

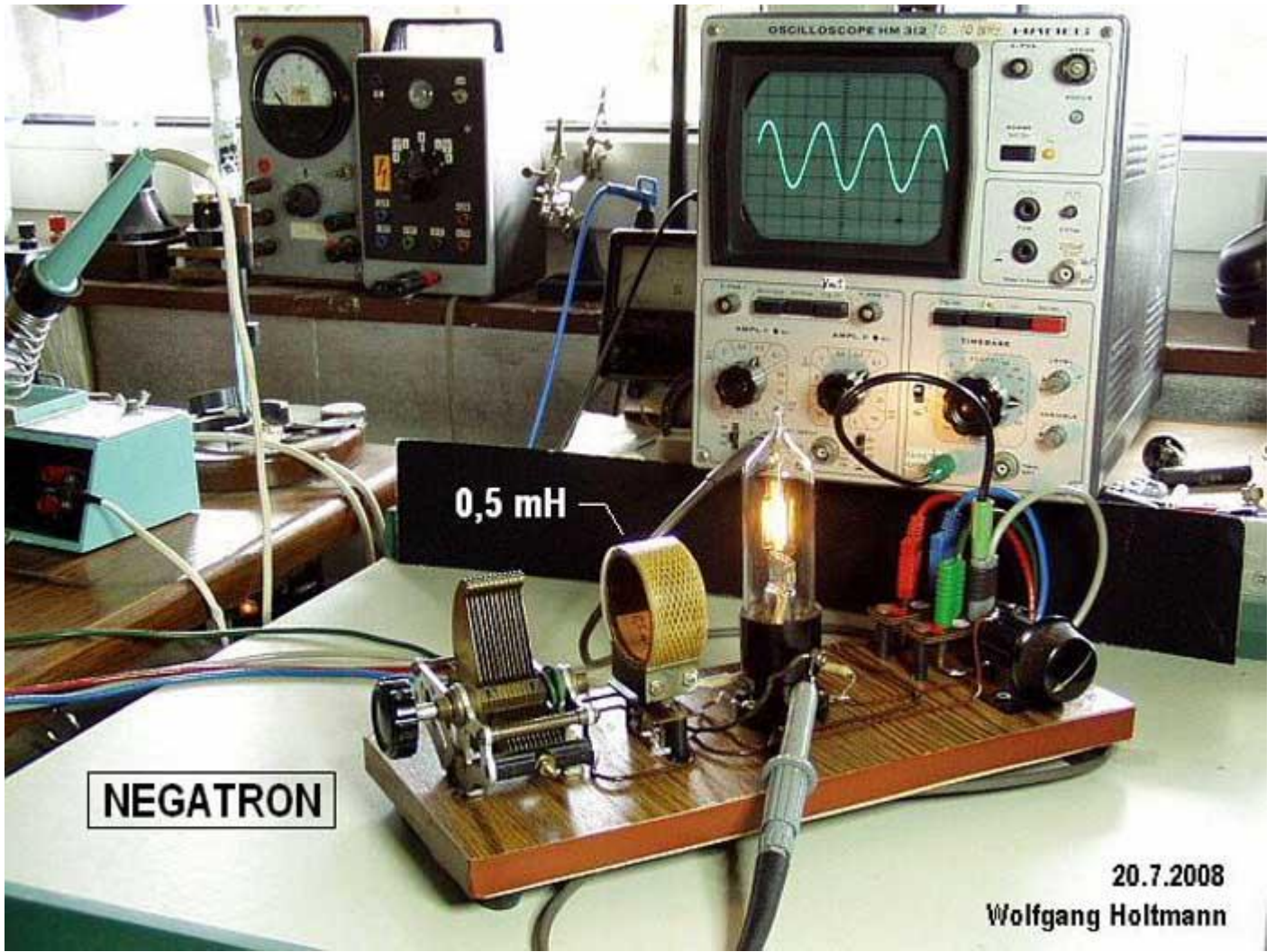
Again, two separate anodes and the control grid inserted only on one side. However, Langmuir had thought of a completely different application. He did not think of the possibilities of vibrational production at that time, I suppose.

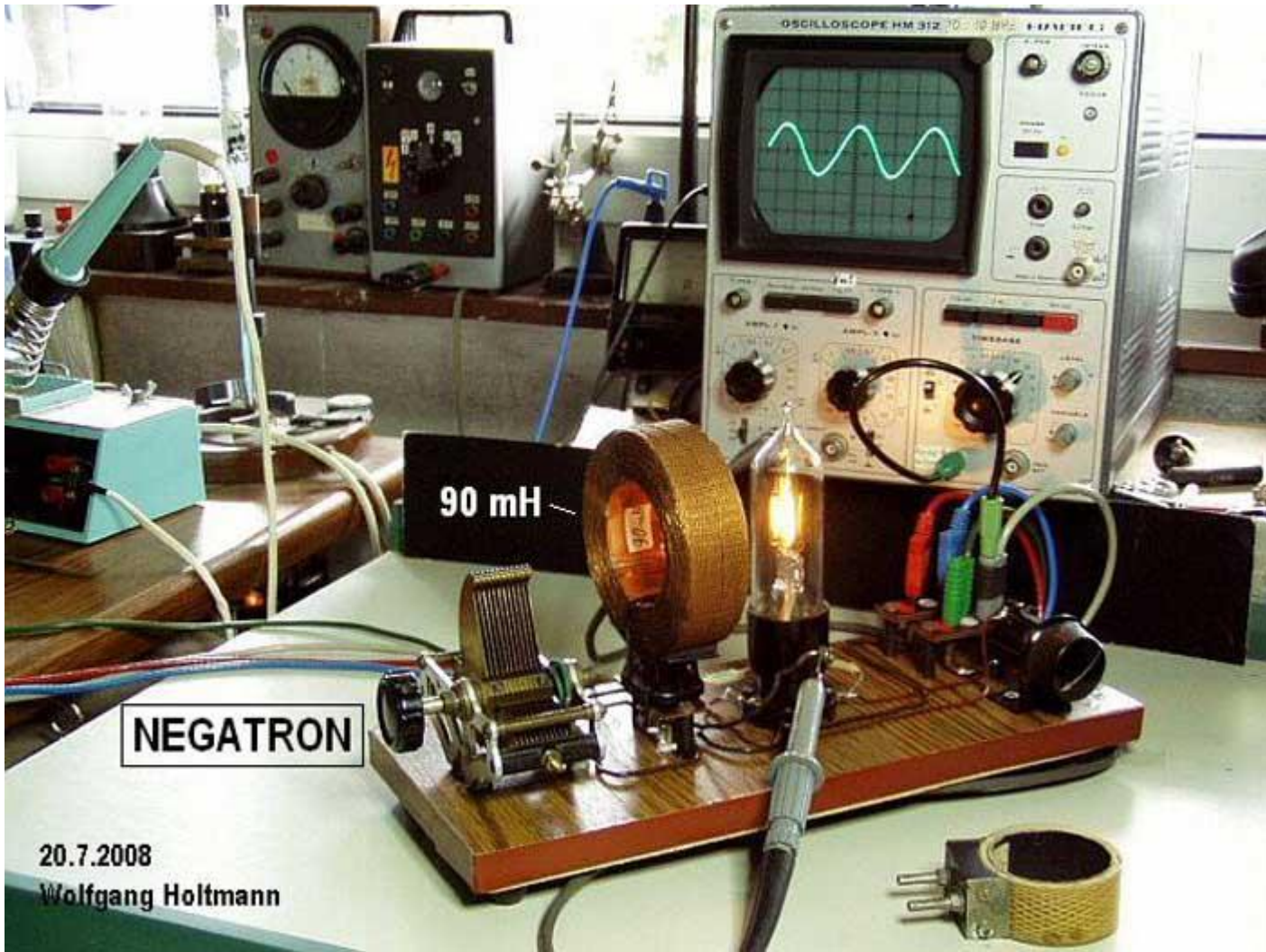
Experiments with the NEGATRON (replica)

Let's just rest the theory and concentrate on the pros and cons of the NEGATRON circuit through experiments.

Next up is the experimental circuit, which I built on a wooden board. It was all about the oscillator function. The big advantage, it is only an inductance-without tapping-required, as well as the appropriate parallel capacitor to it. Amazing is the oscillating power of the circuit with simultaneous relative purity of the sine wave! And that over a very large frequency range!

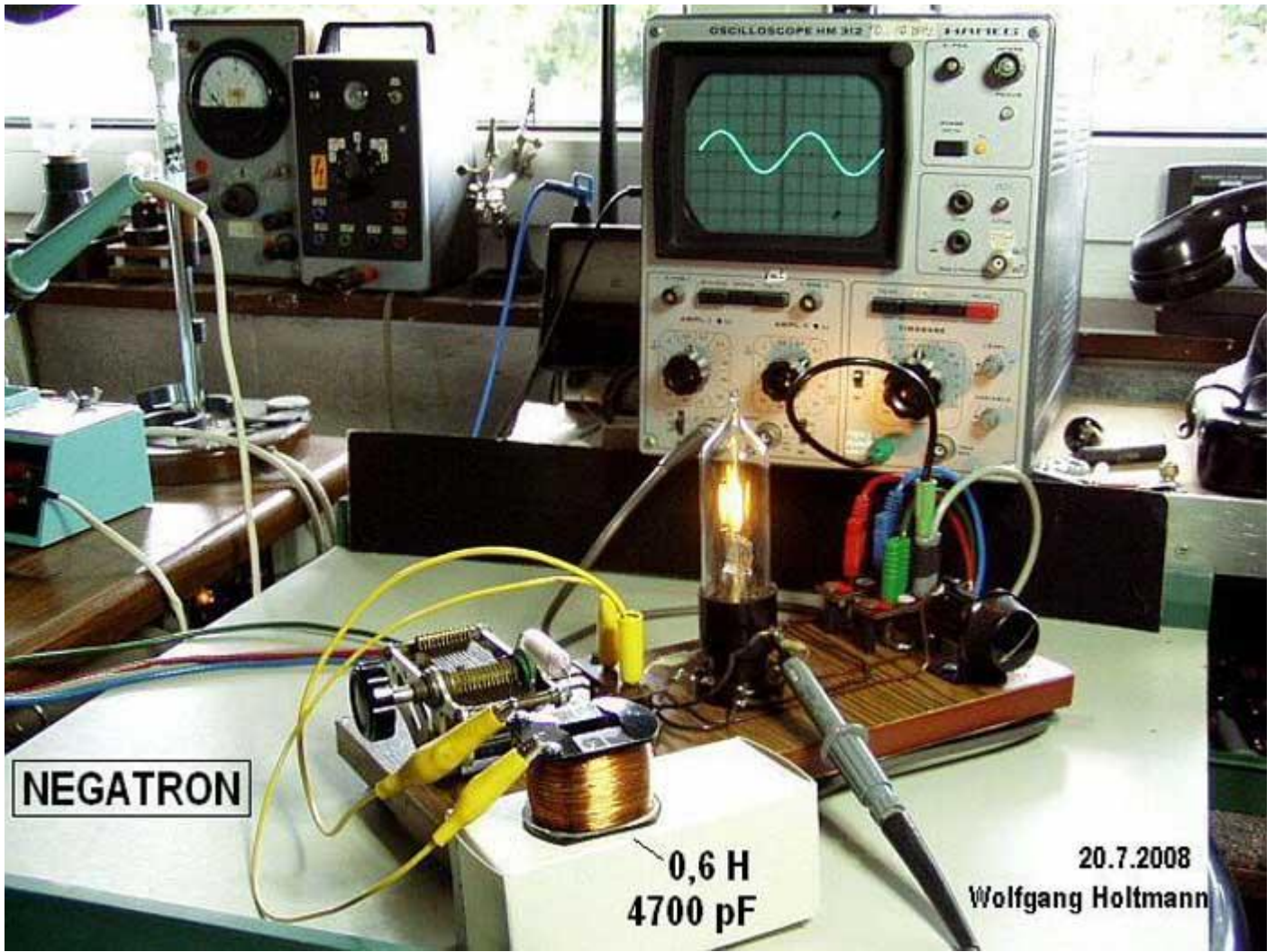
The exception was the mains transformer (primary winding 25 H) with its iron core. The grid capacitor (300pF) always remained the same. Yes, even with a 100k resistor, I was able to stir up vibrations.





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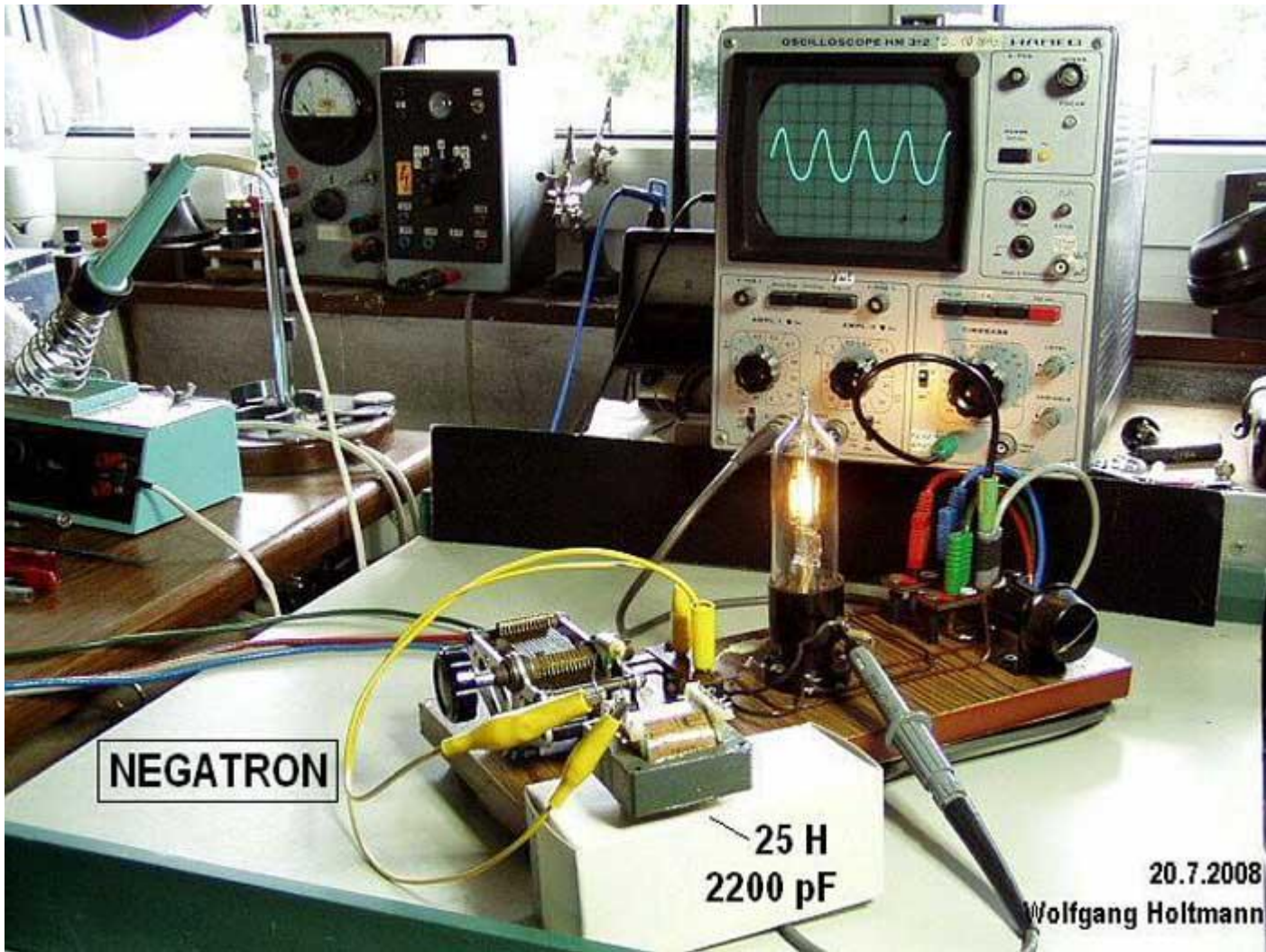
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NEGATRON

0,6 H
4700 pF

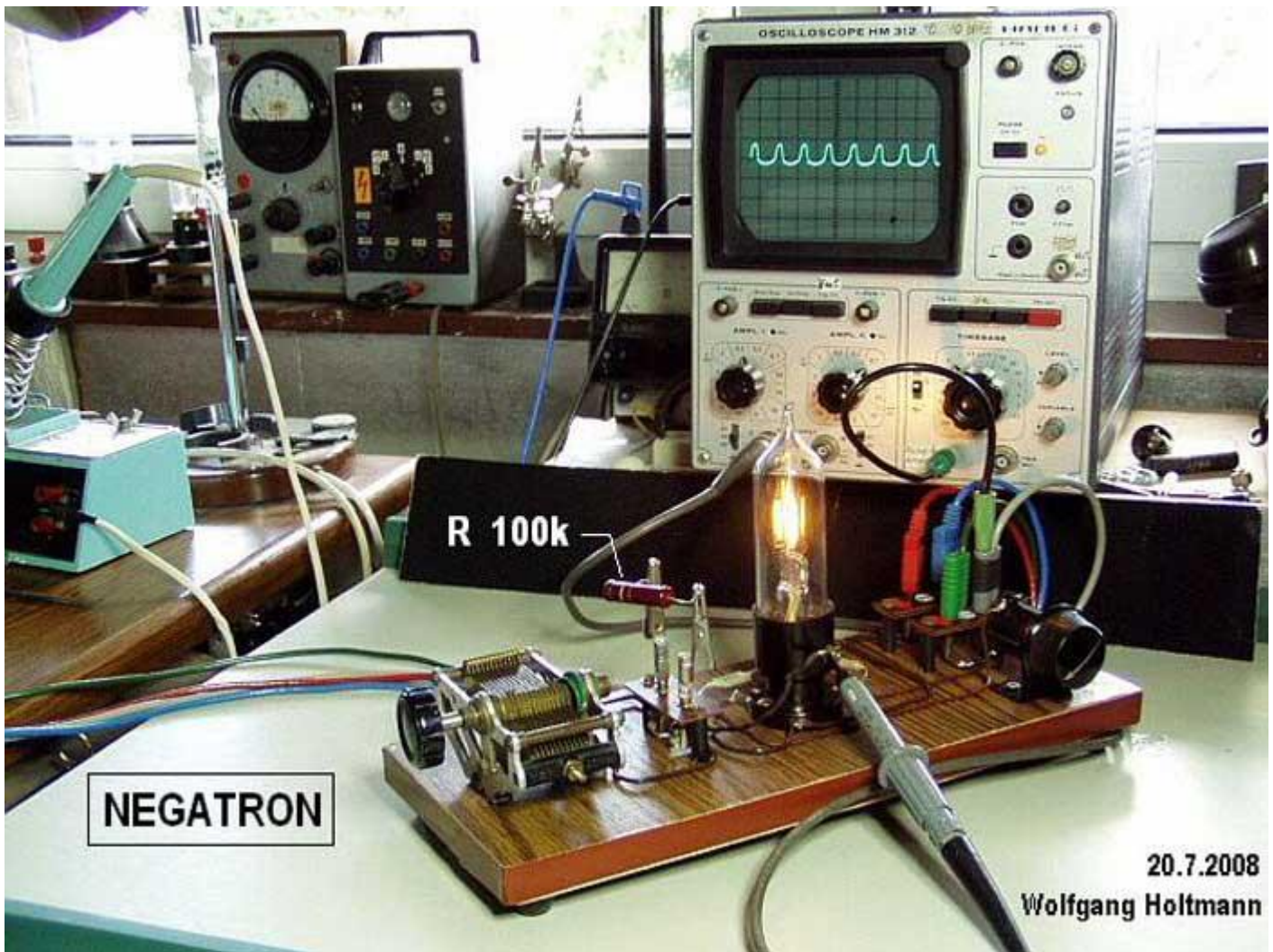
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NEGATRON

25 H
2200 pF

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But also a disadvantage should not be concealed: The maintenance of the vibrations is very much dependent on the filament tension, less of the anode voltage! The characteristics of the characteristic curves shift even with small changes. So was in my attempts to keep the heating voltage in the range of 3.3 to 3.6 volts. Above and below the vibrations break off! I already noticed this effect with the NEGADYN circuit.

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