Home-made Electron Tube Replica

by Dr. Rüdiger Walz

In June 1983, my meanwhile late friend Franz Pemmerl and I started with our hobby to rebuild old radio electron tubes.

A lot of things had to be learned and a lot of failures taught us how to build tubes. For all those who dream of making thermionic tubes as a hobby I like to give an insight into my hobby workshop.

Repair or Rebuilt ?

A lot of people collecting vintage radios dream of repairing of especially rare tubes. In the 1920ies this has been the service of several small companies. So why do we not repair tubes today?

There are several arguments not to do it:

1) All old tubes are today historical artefacts and not items of daily use. A repair procedure would destroy writings and the original shape of the bulb. The function as a historical artifact would be irreversibly destroyed.

2) You would need a lot of different materials, glass types, tungsten wires etc. to repair old tubes. Every repair is a sole action and would need high skills and training in glassblowing.

3) By experience we found out that the glass has become brittle after decades and even a professional glass blower failed to warm up and repair a tubewithout cracking of the glass. The same problem occurs if you try to melt in an old press into a new bulb.

4) It is necessary to remove the base of the tube and the copper wires are corroded within the last decades. So in most cases it breaks just were it comes out of the press.

Making a replica is much easier. You start with new raw materials. Depending on your skills the replica looks more or less like the original tube. It was our aim to keep as close as possible to the production process, the used materials and the shape of the original tubes even if in the meantime better materials or constructive solutions would exist.

The starting point

Starting point of our workshop was a vertical turning lathe of the 1940ies from the company Gladitz which built a lot of glassblowing tools in former times till the 1960ies. You can make the press and melt the system into the bulb using this machine. It is not automatic but makes handling of the glass easier for a non-professional glass blower like me. You will see below pictures of making tubes on this machine.

1 Gladitz glassblower vertical turning lathe

Decision for the Type of Replica

For the above reasons we decided to make tube replicas and not repairing tubes. The replicas should be as original as possible.

So what types of tubes can you make in a hobby workshop? We decided it should be tubes of the early 1920ies because end of 1920ies the tube technology has already been on a high level. Indirect heated cathodes and oxide coated cathodes had been developed. The grid construction already needs special machines for producing it. Tubes of the end 1920ies are today still easily available apart from some special types so there is no need for replica from the end-1920ies. Early 1920ies tubes can still be made by hand with a limited need of special machines and tools.

3 Original TM "Metál"

2 Orignal TM

The early tubes look very attractive and have been used outside on top of the radios in many cases. They are visible and if you lack of a replacement your radio does not look nice. The early cathodes glow bright and people who have some still working original tubes are reluctant to use them and would be happy to enjoy the performance of an old radio with bright emitting tubes.

5 Vitus Mondial from 1922 with tube replica

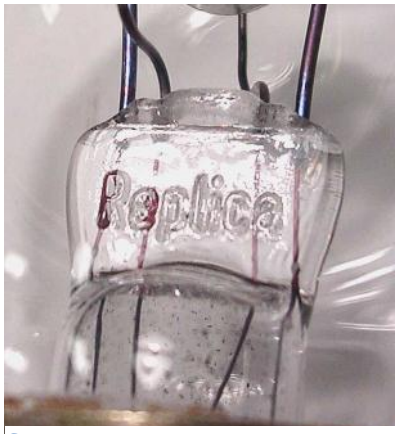
So we decided to make the French “TM” tube or in Britain called “R” tube. It has been developed in World War I in 1916 and has been used on early radio sets. As a German type we selected the RE 11 which also has been developed in World War I in 1917.

4 Telefunken RE 11

Both tubes have pure tungsten wire cathodes and shine as bright as an incandescent lamp. So they look very attractive and not many specimens survived the last 90 years.

Supply of special Materials

For building tubes you need a lot of special materials. The press is made of special lead-glass were a special wire is melted in. This wire called “Dumet” is made of a piece of iron wire which is copper plated a few millimeters long. At the upper end is a nickel wire spot welded and at the lower end a copper wire as connection to the base-pins of the tube. The copper plated wire adheres to the lead-glass of the press and the iron has the same temperature coefficient like the glass so that no crack occurs which may result in a bad vacuum later. In early times until 1924 in Germany a wire with a platinum middle part has been used. It can be recognized by a silver shape in the press. Dumet wire has a red color in the glass press. So the replica can be determined by the red Dumet wire which has not been used in early original TM tubes. Fortunately Dumet is still used in light bulb production and available.



6 Press with Dumet wire

The glass of the bulb has to be so called “soft glass” which fits to the lead glass of the press. We didn’t use modern laboratory glass types because they have a higher melting point and are not so easy to handle on our machine.

Starting materials are glass tubes of different size for the press and the bulb. Also nickel sheet and wire for the anode and grid was not easy to obtain. The tungsten wire for the filament could be bought at companies still producing for the incandescent lamp industry but to calculate it’s shape by tables from old books made every order a risk.

In the 1980ies was no internet so I had to search for suppliers by telephone and “Who delivers what” books. After 9 month telephoning we got all materials and started building tubes !

The first trials – the R - tube


8 "R" Replica vertical system

When we started it was not clear to us if it would be possible to build tubes in a hobby workshop. What would be the difficulties? Will we be successful? Would all the money we spent in vain? Where to get the “know how”?

I am a chemist and at that time I used vacuum technology in handling very sensitive chemicals. I also had some experience in glassblowing. The rest I learned from books of the 30ies about tube making. My friend Franz Pemmerl had experience in metal working and electronics and had space to build up the first workshop in his garage behind his house.


7 TM Replica horizontal system

The first prototypes we build together with a glassblower and pumped them at night in the department of chemistry at the university where I studied at that time because we had no own pumping device at that time.

We decided to start with the British "R" tube or called "TM" in France. It is a simple tube as explained above. The bulb fits well to the tools of our machine which has been used for repairing light bulbs in the 1940ies. The original tubes are rare today and because of that they are expensive so it is worth to do the efforts to build a replica.

First we built the British type with a vertical system, later the French type with the horizontal system which is easier to make.

9 self made base (see below)

For the first specimen we made we used light bulbs from defect incandescent lamps. These standard bulbs are unfortunately of 60 mm diameter compared to the original tubes which had a diameter of 55 mm. Believe it or not the human eye can determine this difference easily and the first few prototypes of replicas looked "wrong". They are still in use at some collectors today. Later we ordered 55mm bulbs from a small glassblowing company. The glassblowing showed to be easy compared to the production of an original shaped base. The base was made of drawn brass. Till we found a company doing this job for us we used turned metal bases which do not look so well. Today it is brass with a ceramic looking insert carrying the pins.

The Workshop

11 Pumping device and glassblower machine

We had two rooms of the size of a garage available. Power supply, gas and water has to be installed. Beside our machine which was the starting point of the whole story a lot of other devices are necessary.

When my friend Franz Pemmerls passed away in 1993 I had to move the workshop to my cellar in my house and had to move again in 2009. The pictures show the actual assembly of the workshop. Picture No. 11 shows the pumping device in the right back and the Gladitz machine in the front right. The following picture no. 12 shows the glassblower workplace and the cooling oven for the glass. The last picture shows the spot welding machine for assembling the electron system of the tube.

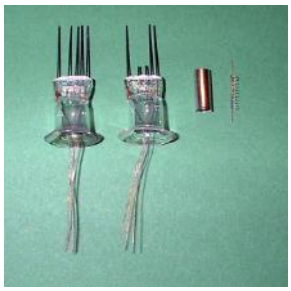
12 Glass blowing workspace and cooling oven

10 The author at the spot welding machine

Making of a thermionic tube

The system of the tube

13 Raw material



14 Press ready for mounting the system

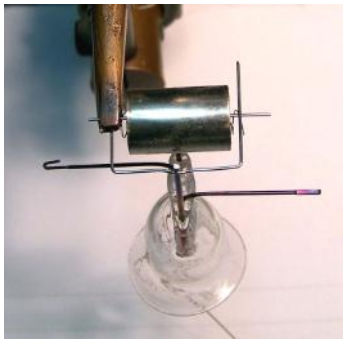
Starting materials are glass tubes which have to be cut in small pieces.

The small tubes are formed to a so called disk. On the opposite side the lead-in Dumet wires are melted into a press (Tool for that see right, press ready for spot welding left). On the press the system is mounted. In the beginning we had no spot welding machine and fixed the system by soldering with copper solder which results in nice red tubes at the end due to vaporized copper on the glass bulb. Later we got an old spot welding machine from a light bulb company. The year and the word “Replica” is pressed into the glass. (see picture no.6)

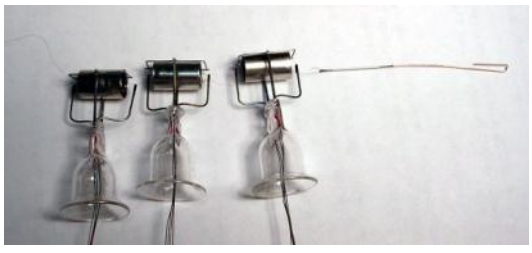
12 Tool for making the press

All parts of the electron system are made by hand. The grid is made on a turning lathe and spot welded and the anode is cut from nickel sheet and rolled. All parts are mounted by spot welding on the nickel wires coming out of the press and adjusted.

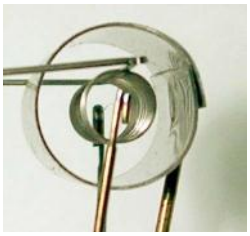
17 Spot welding the grid



16 spot welding the system



15 inserting the filament



18 adjusting the filament

The System is now melted into the bulb using a tool on the Gladitz machine. The system is mounted on a carrier which is a metal tube and adjusted in the bulb. The tool rotates and the glass is heated and due to gravitation the lower part of the bulb moves down and the bulb melts to the plate of the press. The glass tube is cut by a needle flame and falls down. The tube is now taken from the tool and placed in the cooling oven. It has to be cooled down slowly. Otherwise the glass would break.

17 system on the carrier of the tool

18 bulb in the tool

19 adjustment of the system in the bulb

16 heating up the glass with a gas burner

22 The glass softens and melts tight to the disk

20 Removing the bulb with the melted–in system from the tool

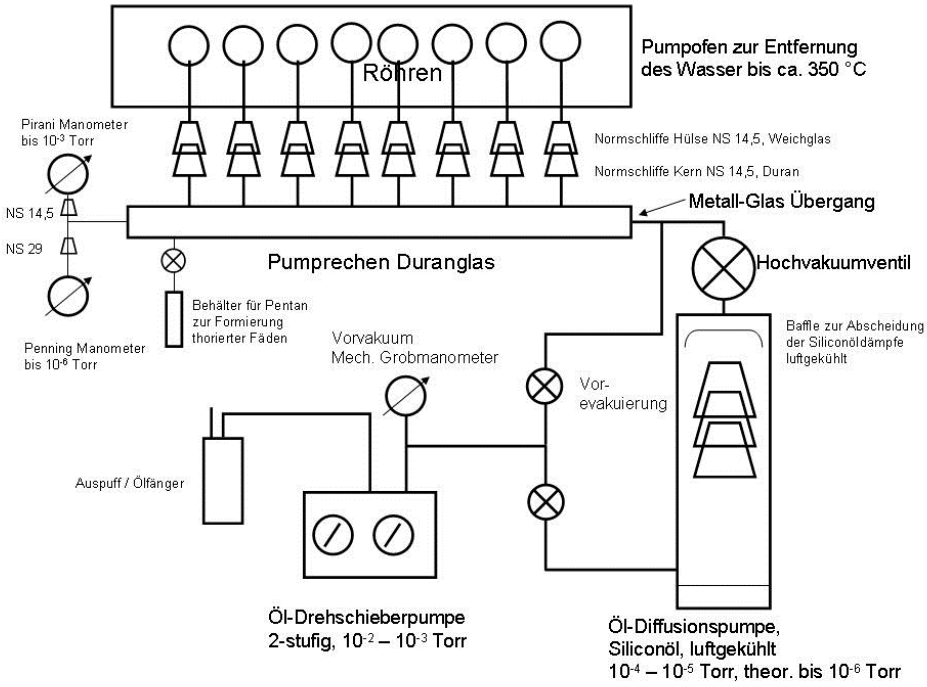
21 tubes in the cooling oven

The pumping device and pumping procedure

The tubes now have to be evacuated on a pumping device. While pumping process they have to be heated to 300 -350 °C to remove the water film from the glass bulb. Humidity reduces the lifetime of the tubes. Because of that the pumping has to happen in an oven which is self-made (see picture).

The pumping device is built according to literature from 1930 – 1960. In theory it can reach a vacuum down to 10^{-6} Torr, in reality after one day running 2 x 10^{-5} Torr. For bright emitter tubes of the 1920ies 4-8 x10^{-5} Torr are sufficient, for thoriated filaments a minimum of 2 x 10^{-5} Torr should be obtained.

The picture shows the principal arrangement of the pumping device.



A two step rotating pump from Leybold provides the first vacuum step down to approx.10^{-2} Torr for the silicon oil diffusion pump from Leybold. No cold trap is used due to the high cost and problems of handling liquid nitrogen. For old tubes this is not necessary. The devices are from 1950 – 1960.

23 Two step rotating pump

24 Oil diffusion pump

A glass tube with 14 standard taper joints (14,5 mm) is connected to the diffusion pump. It is heated to remove volatile molecules and water from its surface in the vacuum.

26 Connection of rotating pump and diffusion pump

25 Vacuum rack connected to the diffusion pump

The joints are below the oven to heat the tubes while the pumping process.

27 Vacuum rack with glass joints

28 View into the pumping oven

The female counterpart to the taper joints is melted to the ready assembled tube coming from the cooling oven.

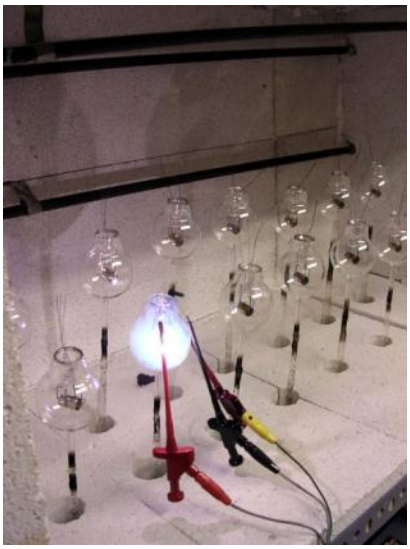
30 Melting the female taper joint to the tube

29 tube and taper joint

The picture shows the complete pumping device with all electronic controls and vacuum measuring apparatus.

32 Pumping device

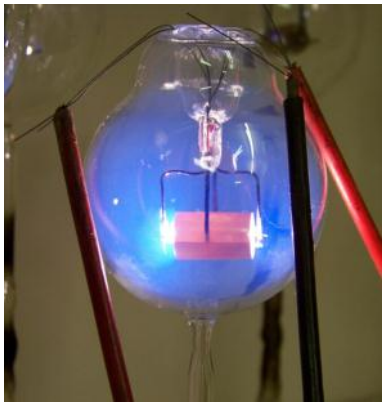
After two hours of pumping a plate and grid voltage of + 200 V is applied and a plate current of 80 to 100 mA (later in use 50 V, 1-2 mA !). The anode becomes red hot and all occulted gasses are removed. The tube glows nicely blue due to ionized oxygen molecules in the bulb. After that the bulbs are melted from their exhaust tube and the characteristic tip is formed.



31 Heating up the anode by electron bombardment

34 Melting off the tubes

The tubes have a writing "TM" or "Type RE 11" on the bulb and a number. This is done with a rubber stamp and a special dye which is fixed by heating up to 500 C. Inside the word "Replica" and the year of making is pressed into the soft hot glass of the press so that the replica can be identified as such. Till the dead of Franz Pemmerl in 1993 the year was signed as "19PWxx" after 1993 "19Wxx" or now "20Wxx".

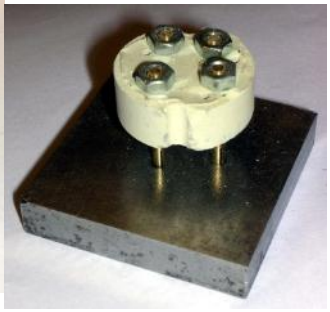


33 Bright glowing anode

The base

As I explained it was more complicated to make an original looking base than the glass bulbs of the tubes. The base is made from brass tubes and we needed some time to find a

37 Tool for pressing the base



38 Insert in the adjustment tool

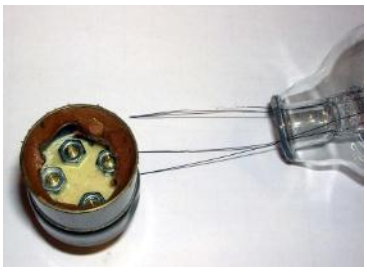
36 Ready assembled base

38 Base before pressing in the tool

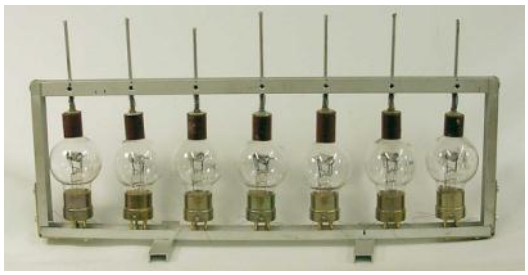
359 Closed tool in the bench vice

company which was willing to make small quantities of raw material for us. The pictures show the brass mantle and the ceramic insert carrying the connector pins placed in a tool to mount the insert into the mantle. The base is pressed by a tool on a bench vice. Today the “ceramic” insert is made from silica filled epoxy resin.

Finally the base is glued to the bulb using a classical shellac/silica powder glue and dried at 120 °C in an oven.



40 Base with glue before mounting the bulb



39 Tool for fixing the tubes for the drying oven

Dull emitter tubes

Beside the "R" or "TM" tube I am also able to build some usual German bright emitter tubes like RE 11 (with Telefunken base) and RE 71 (identical but with European or so called Philips base). The technical standard of these tubes fits quite well to the abilities of the workshop. The systems are a little bit smaller than that of the “TM”. The anodes have a special form and are stamped from a nickel sheet with a special tool.

I managed to get some special filament and I am also able to make tubes like the Telefunken RE 83 (Telefunken base) and RE 89 (European base). These are universal tubes which can be used in every stage of radios till 1927. The more filament current saving counterpart RE 78 and RE 79 I could produce also but the filament is so thin (0,011 mm) that it is very difficult to handle and adjust in the center of the grid.

These tubes require a better vacuum, a getter (in this early developmental stage made from Magnesium) and a special treatment of the filament before use and due to that cause more scrap at production.
In Germany the company Blaupunkt (Blue Spot) supplied in 1926 blue tubes to the market which were produced at HUTH and later at Valvo and Osram. Due to the fact that they are very rare and decorative we decided to rebuilt them. But unfortunately the blue glass is not easy to handle and the exhaust tube is located in the press and not on the top of the bulb. This results in a lot of problems. A lot of trials would be necessary to solve all problems but to find time for my hobby is a problem.

I also did some experiments to make tubes with oxide coated filaments. But this would require new materials and also a lot of trials.

Other hobbyists making thermionic tubes

41 Overview on the made replica types

Meantime I learned that I am not the only one who has rebuilt or is rebuilding tubes but I am the only one doing it now since 1983 continuously.

1986 till 1989 O. Künzel and G. Bogner rebuilt RE 11 in Ulm at the Fachhochschule. Unfortunately the workshop has to be closed due to other use of the room.

Phil Weingarten in USA, a retired glassblower, had rebuilt some DeForest-Audions and Fleming-tubes which unfortunately are not marked as “replica”. He died a few years ago.

In England Gerald Wells and Peter Brian build up a small workshop in the 1980ies and planned to make tubes but I have never seen one. In France M. Beaujean, a retired technician tries to rebuild tubes since 1990. He also makes the bulbs himself, but I have never seen one from him. According to John Stokes, "70 Years of Radio Tubes and Valves" one of the first amateurs who rebuilt tubes was W6IS in the 1960ies in California who makes some tubes similar to R and marked them with "REPLICA Made by W6IS". April 1965 an article was published in QST-Magazine about Sam Diaz Pumara who made non marked tubes which were very crude so that they can be recognized as replicas easily according to John Stokes.

1979 Philip Beckley in England was reported to build some R tubes for his private use which he called "BEB 3". In the 1980ies at the 75 years anniversary of the Philips company some

Dutch Ideezet Type A tubes have been rebuilt by the Röntgenröhrenfabrik Hamburg. They only can be determined by the red Dumet wire in the press in contrary to the original ones. In the nineties VAIC valves (now KR Audio Electronics, Prague producing tubes for hi-end hifi devices) made some TM replicas but they do not do today.

The hand making of vacuum tubes in France is shown on www.youtube.com here: http://www.youtube.com/watch?v=gl-QMuUQhVM.

So a lot of replicas have been built in the last 40 years and they seem to be an item for a tube collector, aren't they ?

At this time some small workshop companies appeared on the scene which make small series of high quality power tubes for high end audio amplifier. The higher the prices for old stock power triodes the more of these workshops will appear. Today they benefit still from the know how of retired tube production technicians. But in a few years these know how will disappear and getting the necessary material will become more and more difficult. Now TV picture tubes are substituted by LCD and the last demand for thermionic tube raw materials disappears.

Future

I had a lot of plans to make e.g. a Lieben tube or rebuilt Loewe multiple tubes or make neon lamps for old TV sets. But all this is time consuming and requires a lot of experiments. Being absorbed by the job and family I do not have much time for my hobby.

I am proud to be successful making tubes on my own. To keep and document a small piece of this old know how is my goal and in 1987 F. Pemmerl and I had a presentation on the AWA annual meeting and I am proud to receive the Tyne Award 1987 for contribution to tube history on this meeting.

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Electron valve
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Radio tube