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The Lieben Valve: a German „universal amplifier“

Introduction

The so called Lieben valve in the form as it was developed from 1910 through 1913 had some impact on the telephone system in Germany and also on the wireless technologies. But the earlier type from 1906, though never used in practice, got more attention in the specialist and public literature. Moreover, the importance of 'the' Lieben valve for the development of the entire field of communications engineering and its related culture has been emphasized in the Austrian and German literature up to the present day, - often without making any distinction as to which type of the Lieben valve was under consideration. Many of the statements and narratives had been motivated by trying to legitimate that the Lieben valve was the first amplifier valve and that the Austrian or German nation could be proud of having such an outstanding scientist and inventor, or such an outstanding innovative industry, respectively. The enquiry, whether the valve of Robert von Lieben, of Lee de Forest, or of some one else was 'the first' amplifier valve, belongs to the tasks of patent offices – and it actually kept them occupied for about ten years early in the last century. For an historian, this is, however, a second-rate question. So my paper, which I want to present to you today, aims to investigate some other topics by deconstructing some of the myths surrounding the development of the early thermionic and vacuum valves.

First I want to look at the development of the Lieben valves with regard to its relations to natural and engineering sciences as well as to industrial and handicraft production capacities. This obviously involves economical, political and cultural aspects embedded in the endeavors of the German Empire to gain more power among the imperialistic nations. Then I want to show how the Lieben valve was destined to become a modern technological component. The symbolic capital of the Lieben valve – so my final point – specificly conjoined to the stress which was laid on the development of valve circuits, thus improving the learning base of industries dealing with communication systems and devices.

I Robert von Lieben, a more or less independent scholar

It is well known, that the affluent Robert von Lieben never finished school or took any examination at all. Nevertheless, he became a student and finally friend of the worldwide respected professor Walther Nernst in Göttingen in the winter semester of 1899/1900, i.e. at the age of 21. There he deepened his understanding of the currently discussed physical and chemical problems and investigated, for instance, the behavior of electrochemical phonographs. While running his experiments, he became interested in problems of amplifying voice signals, that is of problems he was later also confronted with in his telephone fabric which he bought some years after his return to Vienna in 1901. In the meantime, he dealt in his private laboratory with electrical discharging phenomena in gases – a then prominent topic in physical research.

In this period, the physicist Arthur Wehnelt successively published his experiments on tubes with hot oxide cathodes and cold anodes which produced easy to deflect, slow electrons. Von Lieben tried to exploit these new effects for the realization of his idea to build an effective amplifier for electrical voice signals. Having the experiences from his former work in electrical engineering (gained from his work at the Siemens-Schuckert-Werke in Nürnberg), from his physicochemical studies in Göttingen and from his physical investigations in his private lab he seemed to be quite well prepared for such a task. But he also had to hire some experts in order to get the attendant mechanical and chemical problems solved. And it is well known that Richard Leiser, Eugen Reisz, and Siegmund Strauss made essential contributions to the construction of the various forms of von Lieben's vacuum and thermionic valves.

It is not the place here to go into all of the technical and scientific details which became relevant in order to get the amplifiers to work. Let me just point to some of the crucial aspects which illustrate the complex relations between these devices and the conditions in science and industry in the German Empire at the beginning of the 20th century.

As already said, the idea of amplifying analogue electrical signals occupied Robert von Lieben since 1900 when he was working on the electrochemical phonograph in the laboratory of Walther Nernst. Getting acquainted with the experiments of Arthur Wehnelt some years later, he tried to obtain the required effects by influencing cathode rays. He more or less succeeded and applied for a patent in 1906. **(Liebenroehre2)** The all-embracing claim which was formulated in this patent, that is the claim of being able to amplify electrical signals of any frequency by feeding the tube with signals, which were induced either in an electromagnetic or electrostatic way, did not seem to correspond with his initial intention to build just a telephone relay. And it might not be entirely wrong to say as one of his collaborators assumed that von Lieben actually aimed to write a scientific paper for a physical journal. But von Lieben´s dealing with problems of how to amplify analogue signals seems to me primarily due to the form of investigation he could learn at

the outstanding institute of Walther Nernst where technological research was integrated into scientific research and the results of this work were exploited industrially as well as scientifically. Additionally, as a man who was financially and institutionally independent, Robert von Lieben was able to switch easily from one perspective to another by having the freedom to concentrate on whatever topic he was interested in and to hire people who were able to support him.

It is well known in the history of technology from the early period of electrical power and communications engineering that men who had no special institutional ties often elaborated devices or processes which would become crucial for the technical development. To some extent, Lee de Forest also belongs to this group. And we know, too, that the time of entrepreneurships like that of Thomas Edison had come to an end in the late nineteenth century. In order to get some deeper insight into the conditions of these phenomena we should continue to follow the course of development the Lieben valve took. But we can already see that frequently used historical theories such as the scientification of technology or the emergence of applied sciences will neither fit the development of technical and physical electronics nor explain the similarities and differences which appeared during this early period of electronics in different countries.

Robert von Lieben and his collaborators were fascinated with their solution for amplifying signals in principle and they could impress people like Walther Nernst by presenting their device. But they also knew that there still had to be a lot of work done in order to transform the prototype into a reliable device that could be sold on the market. To the basic problems they had to overcome belonged getting a high and stable vacuum as well as to choose or create suitable materials for the electrodes. In both fields they could not refer to sufficient experiences in science or technology. Being experts in different fields in natural and engineering sciences, Lieben and his collaborators systematically varied every constructive detail and the composition of the materials of the electrodes. To overcome the problem of obtaining a high vacuum – a problem that could not to be solved with the air pumps then available – they decided to switch to valves filled with a certain amount of mercury vapor. Following this path meant they had once again to take part in the discourses on electrical discharge of gases, especially on the effects of ionization. In doing so, the Lieben valve changed radically. The two patents from 1910 show the different constructions, especially the introduction of the grid which can be understood as a simplification of the former arrangement of the electrodes – thus making the valve more reliable. Nevertheless, there were still problems as regards the dependence on temperature and the stability of the pressure of the mercury vapor. **(Liebenroehre3)**

The switch to the new type of the valve was mainly due to suggestions made by Reisz and Strauss. Von Lieben would rather have to continued his way of deflecting the cathode rays magnetically. Although led by theoretical assumptions, the design of the valve eventually became a result primarily due to constructive requirements and controllable electrical and mechanical effects. This was the moment when the private laboratory of von Lieben and his collaborators had to refer to the experiences made in industry – for instance in evacuating glass tubes, in handling different materials, and in producing series of tubes of similar quality. But they could present comprehensive patents and also a perfect circuit of how to operate the valve. So von Lieben negotiated with some companies in Germany, and eventually the so called Lieben consortium was founded in early 1912. **(Liebenroehre4)**

II The Lieben consortium and its impact on the Lieben valve

The Lieben consortium consisted in the Allgemeine Elektricitäts Gesellschaft (AEG), the Siemens & Halske AG, the Felten & Guilleaume Carlswerk AG, and the Gesellschaft für drahtlose Telegraphie GmbH, Telefunken. Most of the work for the improvement of the Lieben valve was done in the Telefunken laboratory which was situated at one of the AEG plants. But the Siemens & Halske AG also run some experiments on its own at their electric-bulb laboratory. All of the companies had experiences in dealing with different types of detectors and amplifiers, with glass tubes and the phenomena of electrical discharge, and so on. But their motivation and their dealing with the Lieben valve differed to a great extent. **(Liebenroehre8)**

Siemens & Halske was mainly interested in voice amplifiers and could rely on its experiences made with mechanical telephone relays and with the materials of filaments in the physicochemical laboratory, a small adaptation of the famous lab of General Electric. It especially concentrated its work on the design of the cathode by using materials such as tantalum and tungsten. But it had to learn that the problems of evacuating the tubes was much more difficult than that of electric bulbs. So they tried to take advantage of the ionization effects in the amplifier tube as much as they could.

Telefunken, on the other hand, was mostly engaged in wireless telegraphy and was looking for good high-frequency amplifiers. It had tested the Fleming valve and some devices of Lee de Forest but had decided to abandon the development of such instable and fragile devices. Nevertheless, shortly before Telefunken became aware of the Lieben valve in 1911, it had demonstrated how to use the Audion as a high-frequency amplifier and how to increase the amplification rate by connecting several Audions in the form of a cascade arrangement. So the

Lieben valve could be seen as an alternative to the construction of amplifiers by avoiding the purchase of the patents of de Forest. **(Liebenroehre7)**

The AEG, finally, had just begun to compete with Siemens & Halske on the market of communications engineering. So it was primarily interested in the construction of telephone relays in order to avoid, for instance, the pupinization of cables of which Siemens & Halske owned the patent rights. The technical development of the Lieben valve had to be done, however, mainly by its subsidiary company Telefunken.

The national competition of the companies dealing with communications engineering was forced by the German Post Office and by the military. But these efforts were superimposed by the claims of the government of the German Empire which wanted to attain a stronger position amongst the imperialistic nations. On that level, the promotion of science and industry was regarded to be crucial in gaining the political, economic, and military predominance. So partial alliances of the companies were highly estimated and supported. Despite the specific interests of the companies and despite the role the Lieben valve could actually play in the different fields of communications engineering, the Lieben valve seemed to have the potential to become a universal component in all fields. And as soon as the Lieben valve appeared in the scientific and technological public it was connoted with terms like 'free of inertia', i.e. with terms then connected with modernity, with hopes for the future. Regardless of the deficiencies the Lieben valve inherited, the development of the Lieben valve seemed to be legitimated in several contexts and the respective results were advertised by emphasizing its modern, universal character.

While Siemens & Halske tried to improve the elements of the valve in its modern physicochemical laboratory, i.e. in a laboratory proposed to convey research free from production purposes, the development at Telefunken followed its established forms of combining manual work with the application of scientifically produced effects. In opposition to the Siemens lab, most of the developers at Telefunken were mechanical engineers who tried to avoid any incorporation of physical theories into their daily work. And the management of Telefunken had a hard job in convincing its engineers to return to glass constructions which were seen as pure physical instruments at that time. But there was also a disagreement amongst the Telefunken engineers whether the damped waves or the continuous waves would have a realistic future. The arrangements for using the tubes as low and high frequency amplifiers and finally in feedback circuits as oscillators supported the prospects of the protagonists of the continuous waves. And shortly after the AEG had its first success in presenting its amplifiers to the Imperial Post Office for the use in telephony over wires the Telefunken company advertised the Lieben valve as a "universal amplifier". It has to be emphasized that Telefunken did not mean the

Lieben valve in itself but the entire circuit of the amplifier wherein the Lieben valve was the central component.

Feedback amplification meant in this context not only the use of the Lieben valve in transmitter circuits. In 1913, the Telefunken company was able to equip the receivers at the Nauen station and its counterpart in the USA (Sayville) with Lieben valves in feedback circuits thus improving to a high degree the reception of the weak signals coming over the Atlantic. **(Liebenroehre5)** To put it in technical terms: the already known heterodyne principle proved its worth in practice for the first time and the beat reception strengthened enormously the protagonists of continuous waves – not only in Germany. On the one hand, this meant an advantage in the international competition with respect to the mastery of valve technology. On the other hand, the use of feedback circuits was considered to have shown the potential value of valves as central components in both transmitters and receivers. In the same year – shortly after the early death of Robert von Lieben – Egon Reisz presented the Lieben valve to national and international audiences.

It is well known, that Siemens and Telefunken switched to the development of vacuum tubes in early 1914, but AEG continued to produce Lieben valves for use in civil and military telephone networks nearly until the end of the First World War. The change from gas-filled tubes to vacuum tubes was mainly due to the instability of the Lieben valves caused by temperature variations. But the change had no theoretically evaluated legitimation, and the publication of the investigations of Irving Langmuir in Germany more than a year later only confirmed the intelligence of this change ex post.

III The symbolic capital of the Lieben valve and its economic value

The experiences the German engineers and physicists gained from their dealing with the Lieben valve can be interpreted as an apprenticeship in dealing with glass tubes intended to produce an amplification effect in a predictable – or at least – in a foreseeable way. The comprehensive claim of the first Lieben-valve patent in 1906 could be regarded as a moral right and also as a social commitment to participate in the development of a modern communication component in the frontline of international competition. Terms such as "inertia free" and "based on scientific knowledge" were coupled with a great variety of existing or up-coming applications of this component, -- i.e. terms which were generally used in the rhetoric of the German Empire to describe modernity. So "the" Lieben valve finally had to become a modern German component – despite its shortcomings and despite the circumstance that many of its applications were recognized only successively during its development period.

This point of view can be contrasted with the actual development of the valve. The switch from a vacuum tube to a gas-filled tube made the Lieben valve even less "inertia free". And this caused a lot of problems which could not be overcome during the early phase of innovation. The professors at the Technical Universities did not yet care about the problems which arose from the high-frequency technology, and the efforts undertaken by physicists in the labs of universities and industry were not very successful. The French word 'bricolage' would aptly describe the procedure run by German engineers in order to achieve technologically acceptable results. The problems which the operators of the Lieben valves experienced by operating the amplifiers at changing temperatures were known but could not be solved. The Lieben valve was advertised to work at temperatures form 15^0C to about 30^0C, - not of advantage during the wartime when it had often to be operated below 10^0C.

Nevertheless, the potential of the Lieben valves from 1910 on could be demonstrated by the creation of various circuits for amplification or oscillation effects. And it was not regarded as meaningful that sometimes these circuits were achieved by using the at that time also imperfect Audions of Lee de Forest. In the USA, for example, the path from vacuum tubes to gas-filled tubes and back to vacuum tubes was also pursued by Irving Langmuir. But Langmuir saw his investigations into ionization effects only as a limited attempt in order to achieve deeper insights into the behavior of electrons in a less than perfect vacuum.

In the long run, the three main patents of Robert von Lieben, which were owned afterwards by the so-called Lieben consortium, and the patents relating to the circuits brought the German companies of this consortium, and especially Telefunken, in the happy position of determining the German market in the field of electronic communications engineering up to the early thirties. And of course, to speak with Alfred Chandler, this strengthened their learning base and gave them eventually the major role in consumer electronics not only in Germany but also in Europe. The Lieben valve itself never became the central element in electronics but it became the symbol for a "German universal amplifier".

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captions
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Liebenroehre2
first Lieben patent, 1906

Liebenroehre3
third patent 1910: Lieben, Reisz, Strauss

Liebenroehre4
amplifier with loudspeaker, demonstrated in Berlin 1912

Liebenroehre5
receiving station in Nauen, ca. 1914

Liebenroehre7
feedback amplifier, Telefunken 1913

Liebenroehre8
Lieben valve and contract of the 'Lieben consortium'