Scanning our Past from the Netherlands

Bernard Tellegen and the Pentode Valve

Just over 30 years ago, it was announced that the IEEE was awarding the 1973 Edison Medal to a non-American for the first time. This prized recognition for "a career of unusual distinction" was awarded to B. D. H. Tellegen, specifically "for a creative career of significant achievement in electrical circuit theory, including the invention of the gyrator." This was just one more milestone in a very productive life and professional career that included pioneering developmental work early in his career on the vacuum tube known in Europe as the pentode valve.

I. Tubes for Safer Radio Design

Bernardus Dominicus Hubertus Tellegen (see Fig. 1) was born on 24 June 1900, in Winschoten, the Netherlands. After finishing high school in Utrecht, the Netherlands, he went on to study electrical engineering at the Delft Technical University, Delft, the Netherlands. He graduated in 1923, after which he started working at the Philips' Electronics Research Laboratories. This Dutch company, which has been one of the world's biggest producers of light bulbs ever since its founding in 1891, had been focusing on the production of electron tubes. To support this activity, Philips had contracted Balthasar Van Der Pol in 1922 to create a research program within the laboratory, concerning radio technology. Tellegen, who became one of Van Der Pol's first co-workers, dedicated the first years of his career to the properties of triodes. The question that primarily intrigued him was how a triode could be modified to function as a distribution amplifier tube in a radio transmitter.

This problem was accentuated when the company decided not to continue acting solely as a supplier for the radio industry, but to get involved in the production of complete radio receivers as well. Because of safety concerns, a new voltage standard was established for the amplifier tubes that were to be used in Philips appliances; namely, that high voltages could no longer be used. An anode voltage of a mere 250 V was considered too high. To his credit, Tellegen concluded that Hull's tetrode experiments indicated how a solution could be found for these impeding new design restrictions. On 17 May 1926, he described the advantages of using tetrodes as output tubes in radio receiver sets in his laboratory journal. According to Tellegen, not only could a tetrode supply sufficient power to a speaker, but it could also amplify higher frequencies much better than a triode.

A. Development of the Pentode

In the ensuing months, he tried to find a solution for the negative effects of secondary electron emissions to anodes, which caused an electron current toward the screengrid (see Fig. 2). The introduction of an additional electrode, which functioned as a brake grid when placed between the anode and the screengrid, turned out to be a sufficient solution.

While Tellegen worked on his pentode (see Fig. 3) valve, his colleagues in the research laboratory dedicated themselves to the design and development of the first radio set Philips was to produce. Several designs were put aside when it turned out that the use of the pentode valve allowed the production of a good set with no more than three electron tubes. On 13 January 1927, the decision was made that the set would be equipped "with the new pentode valve as its output valve."

The huge success of the radio receivers, introduced on the market in September 1927, cleared the path for Tellegen's pentode valve, which was quickly accepted and introduced in the radio industry. Although the name Tellegen is often connected to his electric networks theory (as a result of his later work), his pentode development work is associated with only one of his 57 patents, the one for his pentode valve.

B. A Strategic Development

The most well-known pentode type, the EF50, developed by Philips, was designed before the start of World War II, and was used in some prewar television sets. Design details and essential production parts were transported to the United Kingdom just days before the occupation of the Netherlands. This pentode valve was extensively used in radar receivers; it contributed to the electronic preponderance of the Allies, and was often considered nearly as important as that of the magnetron. After the war, Tellegen continued to make many contributions to his profession; in turn, his profession continued to bestow honors on him.

C. Postwar Achievements and Honors [1]

From 1946 to 1966, Tellegen was professor extraordinary of circuit theory at the University of Delft. Adams, Bor-

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Fig. 1 B. D. H. Tellegen (Photograph courtesy of Philips company archives/historiography).

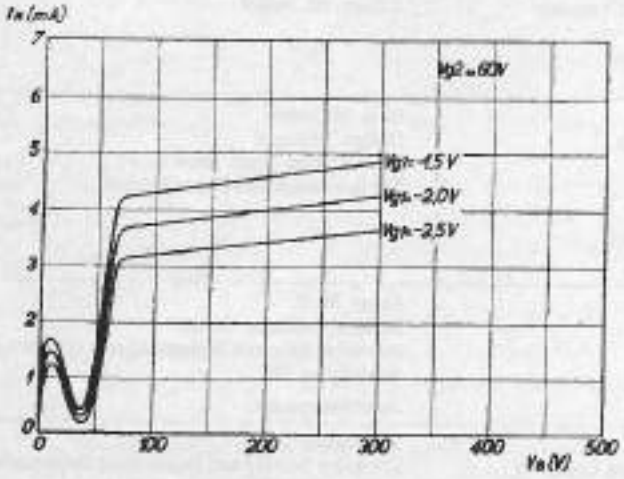

Fig. 2 Tetrode characteristic plot of voltage-input to I (current)-output graph, including what in some circles was referred to as the tetrode kink, which was a result of the negative effects of secondary electron emissions. (Graph courtesy of Philips company archives/historiography).

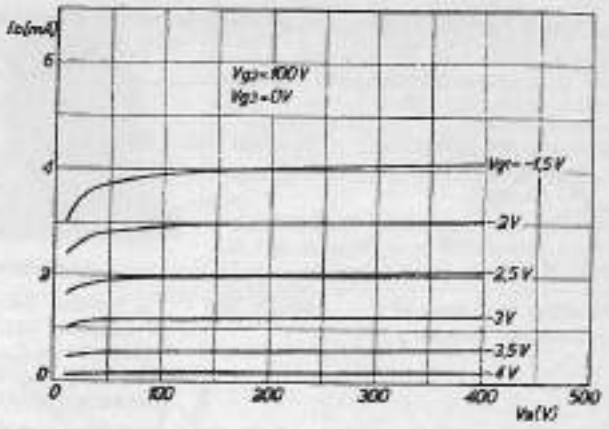

Fig. 3 Graph of voltage-input to I (current)- output of the pentode, which resulted from the inclusion of an additional grid to a tetrode design. (Courtesy of Philips company archives/historiography).

dewijk, and Duinker were among those who received their doctor's degrees working with him.

From 1942 to 1952, he was President of the Dutch Electronics and Radio Society, which made him an honorary member at the end of this period. From 1948 to 1960, he was Chairman of the Dutch Committee of the International Scientific Radio Union (URSI) He was Vice President of URSI from 1952 to 1957. From 1957 to 1960 he was vice chairman of its commission VI, especially charged with circuit theory.

The Australian Institute of Radio Engineers made Tellegen an honorary life member in 1953. He received the Research Prize of the Royal Dutch Institute of Engineers in 1954, the Fellow Award of the IEEE in 1955, and, as mentioned earlier, the IEEE Edison Medal in 1973. Tellegen was elected a member of the Royal Academy of Sciences of the Netherlands in 1960. In 1970, the University of Delft conferred on him the degree of doctor honoris causa in technical sciences.

Dr. Tellegen passed away on 30 August 1990, but his many professional achievements constitute a lasting legacy to this son of Winschoten.

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[1] IEEE History Center. *1973 Award Banquet Brochure* [Online]. Available: http://www.ieee.org/organizations/history_center/legacies/tellegen.html