

A HISTORY OF
ELECTRICAL
POWER
ENGINEERING

PERCY DUNSHEATH



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Scanning our Past from London

Galileo Ferraris and Alternating Current

I. INTRODUCTION

Last month we wrote about the Italian, Alessandro Volta, who in 1800 gave us a continuous electric current rather than the sparks and flashes that characterized electricity in the 18th century. This month's subject is another Italian, Galileo Ferraris (Fig. 1), who deserves to be far better known. His work with alternating current paved the way for others to develop the induction motors and the three-phase transmission of power that we take for granted today.

II. THEORY AND PRACTICAL EXPERIMENT

Ferraris was born in 1847 in what is now northern Italy and graduated with degrees in mathematics and physics from the University of Turin. He was soon appointed as an assistant at the Museo Industriale of Turin, one of the educational institutions that merged in 1906 to form the Politecnico di Torino. Initially his main interests were in optics and in heat, but electrical matters gradually took over. In 1877 he was given charge of the course on technical physics at the Museo Industriale, and in 1879 he became a full professor, remaining there until his death in 1897. He believed strongly that his engineering students should combine theoretical study with practical experimentation, and in 1882 established the "School of Electrotechnology with Laboratory" at the Museo Industriale. He always placed special emphasis on the importance of electrical measurements. One of his earliest papers recorded measurements of the minimum current needed to produce audible signals in a telephone receiver.

When the first International Electrical Exhibition was held, in Paris, in 1881, Ferraris was sent as one of the Italian Government's representatives to the associated Congress of Electricians. He was a prominent figure in the Exhibition, and he took an active part in the debates at the congress. From that time onward his main technical interests were the increasing number of applications of electricity. In 1883 he again represented his Government, this time at the electrical exhibition held in Vienna.

III. A SIGNIFICANT DEVELOPMENT

By 1884, Italy, still a young country having only been united since 1861, wanted its own International Exhibition. This was



Fig. 1. Galileo Ferraris was hailed as "the father of three-phase current" in 1891. (Reproduced from illustration depicting a group of delegates at the Electrical Congress of 1894, from "The Electrical World," August 26, 1894, New York, page 147.)

held at Turin, which had been the first capital of Italy. Ferraris was made President of the Electrical Department of the exhibition. At the exhibition he carried out a practical study, with careful measurements, of the Gaulard and Gibbs transformers (Fig. 2) that were exhibited. These had been used for supplying the electric lighting on the London Underground, and during the exhibition a pair of transformers was used in a demonstration of electrical transmission over a distance of about 40 km from Turin to Lanzo. The power was low, only a few kilowatts, but the demonstration was a significant development in electrical engineering.

At that time little was understood about the theory of transformers, and there were no published studies of their efficiency, so Ferraris' work attracted considerable interest. The following year he carried out similar studies on the transformers of Ziperowsky and others, which had closed iron cores whereas the

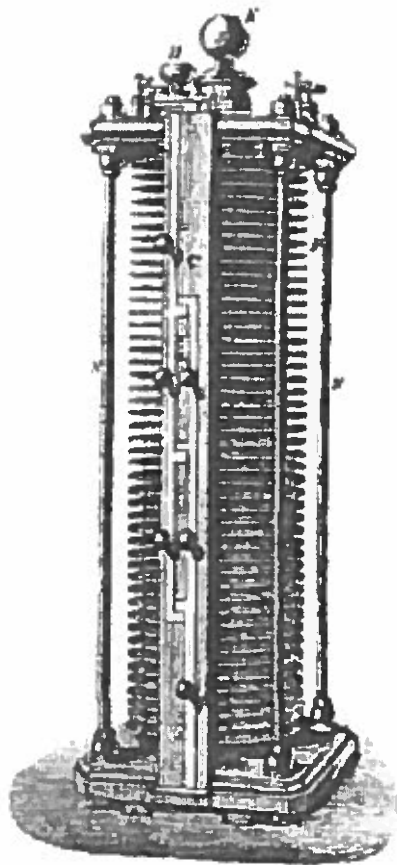


Fig. 2. Drawing of the secondary generator or transformer of Gaulard and Gibbs, which was studied extensively by Galileo Ferraris in 1884. (From *Elektro-Technische Zeitung*, 1885, p. 290.)

Gaulard and Gibbs transformers had an "open" magnetic circuit with the flux path completed through the air.

IV. MOTORS FOR INDUSTRY

At the time of the Turin exhibition electricity was used almost exclusively for lighting, but people were beginning to think about electric motors. The idea that a rotating magnetic field might cause a suitable "rotor" to revolve was not new. Walter Baily, for example, had exhibited in London in 1879 a device in which two sets of electromagnets were switched alternately causing a copper disc to rotate. Ferraris' transformer studies led him to consider the fact that the primary and secondary currents were out of phase. In the summer of 1885 he conceived the idea that two out-of-phase, but synchronized, currents might be used to produce two magnetic fields that could be combined to produce a rotating field without any need for switching or for moving parts (Fig. 3). This idea, which is commonplace to electrical engineers now, was a complete novelty in the 1880s. Ferraris published it in a paper to the Royal Academy of Sciences in Turin in 1888. This was quickly translated into English, and published in the journal *Industries*, later the same year (Fig. 4).

At the time Ferraris seems not to have thought that his principle would lead to a motor (Fig. 5) for industrial purposes, but

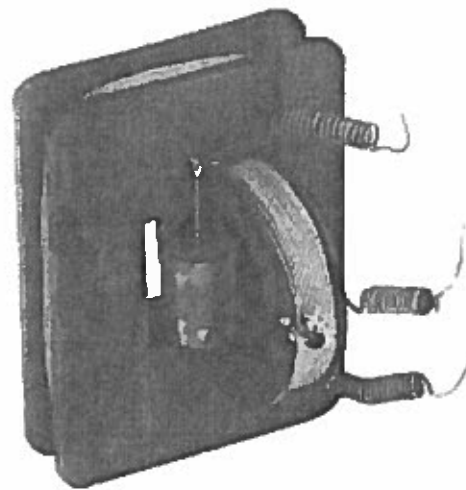


Fig. 3. Recreated copy of Galileo Ferraris' first model of the rotating field motor assembled by Professor Guido Grassi, circa 1899, reportedly with the assistance of the same artisan who had made the original device in 1885. The original models were completely destroyed. (Photo from the Istituto Elettrotecnico Nazionale Galileo Ferraris in Turin, Italy.)

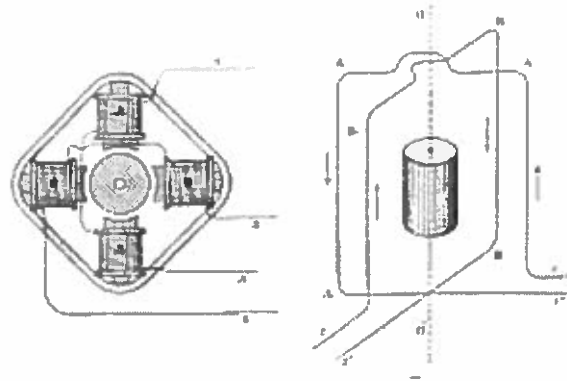


Fig. 4. Schematic drawing of Ferraris' motor showing phases A and B, which allowed heavy industry to more effectively use alternating current (ac) motors. (From SP Thompson, *Polyphase Electric Currents and Alternate-Current Motors*, 1895.)

he did suggest that it could be used as the basis of a meter for alternating current measurements. In 1891, however, he attended the Electrical Congress at Frankfurt where three-phase transmission was demonstrated over a line from Lauffen, more than 100 miles distant. At the Congress Dinner Ferraris was hailed as "the father of three-phase current."

V. A SOCIALLY CONCERNED ENGINEER

Although his laboratory work was vital to him, Ferraris found time to use his abilities as an engineer in the service of the wider community. In 1897 he became a city councillor in Turin and proved to be an active councillor especially where his technical knowledge could be of use. Naturally he was closely involved with the electric street lighting of Turin, and he was concerned that the lighting should include the suburbs as well as the city center. Turin had long had horse-drawn trams, and when electric

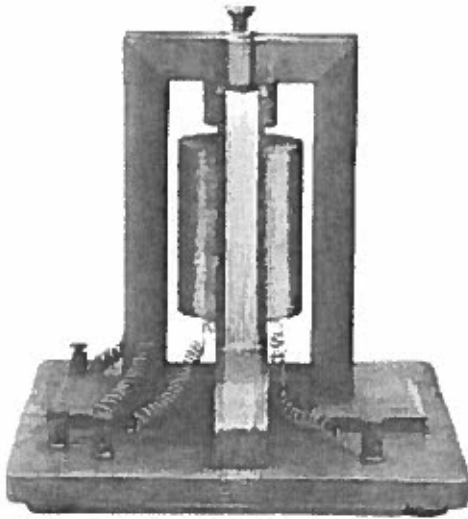


Fig. 5. Recreated copy of Ferraris' second model (1885) of the rotating field motor. (Photo from the Istituto Elettrotecnico Nazionale Galileo Ferraris in Turin, Italy.)

trams powered by accumulators were proposed Ferraris resisted that idea, preferring a tramway system with electrical distribution by either overhead or underground conductors.

Because of his "social" concerns, he argued that electric power should be distributed as widely as possible and available to everyone. He argued, for example, that with electric power in the home a mother might earn money by working at home with a loom, rather than "abandoning her children" by going out to work.

Both for his contributions to electrical engineering and for his work to make the benefits of electricity widely available, Galileo Ferraris deserves to be remembered as one of the great names in our profession.

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