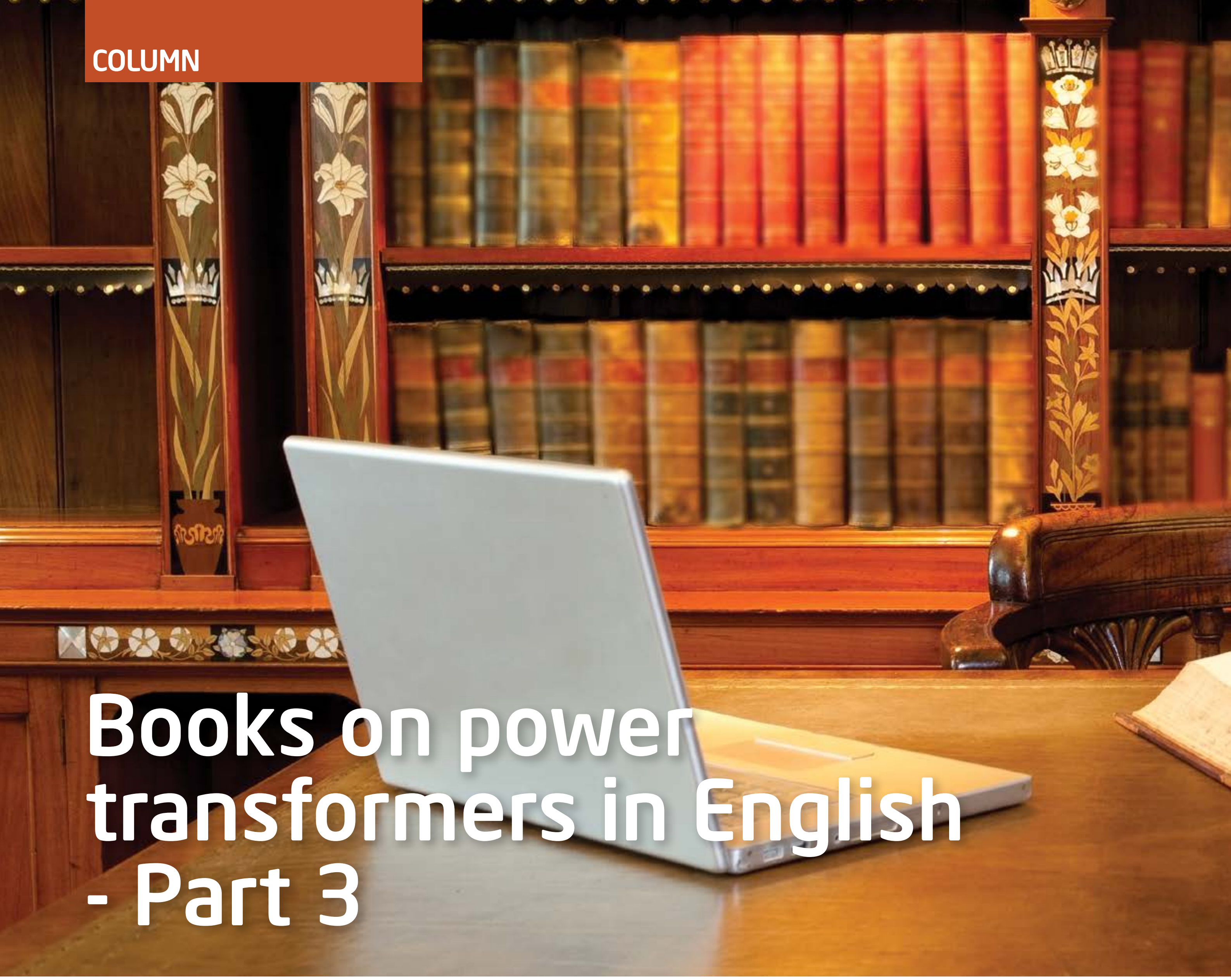

Books on power transformers in English - Part 3

ABSTRACT

Parts 1 and 2 of this series covered transformer books published until 1909. This part covers a transformer book published in the first decade of the twentieth century. In 1909, Alfred H. Avery published a landmark book on autotransformers, laying the groundwork for future advancements in electrical engineering. This article reviews the book's contributions to solving early electrical distribution problems and enhancing lighting efficiency. It also explores the subsequent evolution of autotransformers, emphasizing their role in meeting modern energy demands.

KEYWORDS

literature, books, autotransformers, Alfred H. Avery, transformer innovations

1909

Alfred H Harry, *Auto-Transformer Design*, E.&F.N. Spon, Limited, 57 Haymarket. London, 60 pages, 1909. Accessed at https://archive.org/details/AutoTransformerDesignAvery

The publication of the first (and seemingly also the last!) book focusing exclusively on autotransformers happened in 1909. The book was written by Alfred H. Avery, an electrical engineer from England, and its title was "Auto-Transformer Design: A Practical Handbook for Manufacturers, Contractors and Wiremen with 25 illustrations". A UK publisher reprinted the book in September 2010, 100 years after the initial publication. Seven chapters of the book covered the classification of transformers, modern illumination methods, elementary theory and fundamental formulae, practical design, efficiency calculations and constructional details.

The discovery and experimentation with the auto connection for transformers in the 19th century marked the early years of transformer engineering. However, a true breakthrough and the first significant demand for autotransformers emerged in the first decade of the 20th century. This period coincided with the standardization of 110 or 220 V AC distribution voltage in European countries and the widespread use of electricity for household lighting, primarily through carbon filament lamps pioneered by Thomas Alva Edison. The first patents for incandescent lamps using bamboo carbon filaments were filed by William E. Sawyer and Albon Man in the US, but it was Edison who turned this into a commercial reality.

A significant breakthrough came with the invention of metal filament lamps. It is interesting to note that something similar happened 100 years later when blue LED lamps were developed. Many metals were

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The book covered the design of the transformer with the core built with "Stalloy" brand iron sheets with a working flux density of 0.8 T at rated voltage (200 V) and frequency (50 Hz)

tried for filaments; the winner was the tungsten filament developed by OSRAM lamps. However, the problem was that engineers could not make thin metallic filaments, as tungsten was not a malleable metal. Hence, the resistance of tungsten filament lamps was so low that 50 V AC had to be used to limit the current through the metal filament. The solution was to provide a 200/50 V single-phase air-cooled autotransformer in each house. Still, it was an attractive solution, as we have seen with LED lamps recently. To get an idea of the efficiencies of carbon filament lamps (1880), metal filament lamps (1905), and LED lamps (2005), the lumen per watt of power was 5.15 and 125 lumen per watt, and the lifetime of a lamp increased from 800 hours to 15,000 hours! Lumen is the unit of luminous intensity used by engineers. We can appreciate the energy saving achieved all these years for the same luminous flux from various lamps.

In 1905, electricity was billed at 4.5d (pence) per kWh in London, UK. The cost of a 16 cp (candlepower) carbon lamp was one shilling (with a power consumption of 60 W), while the price of a 16 cp metal filament lamp was 3 shil-

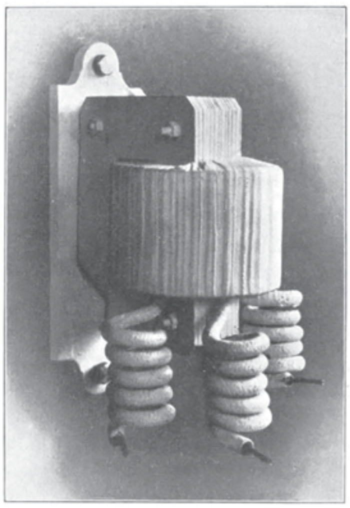
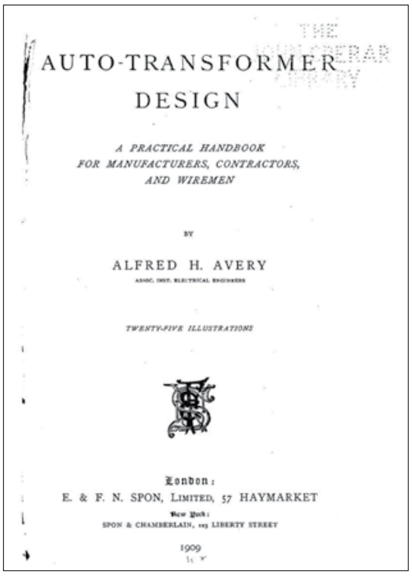


FIG. 24.—PHOTOGRAPH OF THE FINISHED INSTRUMENT MOUNTED ON IRON BACKPLATE.

lings (with a power consumption of only 20 W). A 1 kW (kVA as rating came much later) 200/50 V autotransformer's cost was 2 pounds and 19 shillings. Even after considering the cost of the autotransformer, the extra capital outlay for the metal filament lamp could be recovered by energy savings in the first year of use. This created a sudden demand for a vast number of 0.5-2 kW autotransformers in England, which was the reason for the publication of this book on autotransformers!

The book gives the design and sketches of a 0.5 kW 200/50 V autotransformer for feeding metal filament lamps. Detailed manufacturing instructions are also provided for the windings and the core. The core was built with "Stalloy" brand iron sheets with a working flux density of 0.8 T at rated voltage (200 V) and frequency (50 Hz). In the two-limb core, the windings were provided only on one limb. The current density was 1.5 A/mm2 (1000 A/in2) with round wires. Losses in a 0.5 kW auto transformer were 10/24 W (iron/copper losses) with an efficiency of 93.6 % at full load. The core was built with 15.5 lbs (7 kg) of lamination. The turn voltage used for the design was 0.4 V. Even today, if you apply the famous formula for per-turn voltage, which transformer designers use, then e= 0.7x sqrt 0.5x150/200 = 0.43 V/T! Please see the attached photo of the final product. They were calling it an instrument rather than an autotransformer. Some years later, engineers succeeded in making thin tungsten wires to suit 220 V supply, and all those autotransformers might have been scrapped.


AUTO-TRANSFORMER DESIGN

A PRACTICAL HANDBOOK FOR MANUFACTURERS, CONTRACTORS, AND WIREMEN

BY

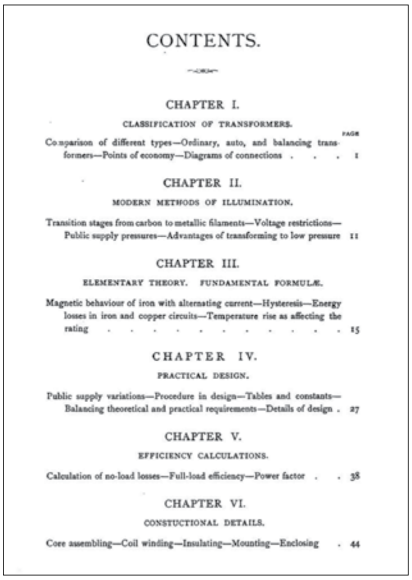
ALFRED H. AVERY

ASSOC. INST. ELECTRICAL ENGINEERS

TWENTY-FIVE ILLUSTRATIONS

London:
E. & F. N. SPON, LIMITED, 57 HAYMARKET
New York:
SPON & CHAMBERLAIN, 123 LIBERTY STREET

1909


CONTENTS.

The largest autotransformers in China have a rating of 4500 MVA bank 1100/500 kV, a long journey from the 0.5 kW 200/50 V autotransformers used in London

Later, when maximum electric transmission voltages doubled with each decade (11, 22, 66, 132, 220 kV), the ideal transformers for interconnection between successive voltage levels were autotransformers, as a voltage ratio of two gave good economy with autotransformers. The unit rating also increased with the increased demand for electric power. In 1970, many utilities in India used to procure 20 MVA 132/66 kV and 60 MVA 220/132 kV 3-phase autotransformers. Today, the demand is for 100 MVA 132 kV and 160 -250 MVA 220 kV autotransformers due to the higher power demand.

The Zaporizhzhia Transformer Plant in Ukraine (now Zaporizhtransformator) has produced over a thousand autotransformers from 220/110 kV to 1150/500 kV, with a maximum bank rating of 2000 MVA. The largest autotransformers in China have a rating of 4500 MVA bank 1100/500 kV, a long journey from the 0.5 kW 200/50 V autotransformers used in London.

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P. Ramachandran started his career in transformer industry in 1966 at TELK, Kerala, a Hitachi Joint venture, in India. He worked with ABB India during 1999-2020. He has more than 50 years of experience in the design and engineering of power products including power transformers, bushings, and tap-changers. He received Bachelor of Science Degree in Electrical Engineering from the University of Kerala, India, and Master of Business Administration Degree from Cochin University, India. He is a Fellow of Institution of Engineers (India), and he represented India in CIGRE Study Committee A2 for transformers during 2002 – 2010.


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