Chapter 1

# Introduction

In many countries the public perception of more traditional aspects of engineering remains at best indifferent and at worst quite negative. Electrical engineering is perhaps seen as mature, unchanging and offering little scope for imagination, with poor prospects for any future career. There is a serious risk in many parts of Europe and North America that substantial areas of knowledge are being lost as large numbers of key experts are retiring without the opportunity to teach and train the specialists of the future. And yet the technology continues to move on, and the understanding of the basic mechanisms of circuits, electromagnetics and dielectrics continues to be as challenging intellectually as it has ever been. There have even been very prominent warnings of the dangers of neglecting the importance of electrical power systems and plant, and of underestimating the value of the skilled engineers necessary to support this infrastructure. The major power failures of the past few years, in the Eastern seaboard of the USA, in Auckland, in Italy, in London and in parts of Scandinavia have highlighted how dependent a modern society is on a reliable source of electrical energy.

So, the need has never been stronger for a basic understanding of principles and a fundamental appreciation of how the major classes of electrical equipment operate. In a handbook, it is not possible to set out a comprehensive treatment but the aim is to provide a balanced overview, and perhaps to engender the interest to pursue areas in more depth. A more complete coverage of all the subjects addressed here can be found in the *Newnes Electrical Engineer's Reference Book.*

The structure of the handbook is, as before, based around three groups of chapters as follows:

- fundamentals and general material
- the design and operation of the main classes of electrical equipment
- special technologies which apply to a range of equipment

The first group covers the fundamentals and principles which run through all aspects of electrical power technology.

The opening chapter deals with the fundamentals of circuit theory and electric and magnetic fields, together with a brief coverage of energy conversion principles.

This is followed by a review of the materials which are crucial to the design and operation of electrical equipment. These are grouped under the headings of magnetic, insulating and conducting materials. In each of these areas, technology continues to move ahead. Further improvement in the performance of permanent magnets is one of the key drivers behind the increasing use of electrical actuators and drives in cars and the miniaturization of whole ranges of domestic and commercial equipment; and the challenges in understanding the behaviour of soft magnetic materials, especially under conditions of distorted supply waveforms, are gradually being overcome. Developments in insulating materials mean that increased reliability can be achieved, and operation

at much higher temperatures can be considered. Under the heading of conductors, there are continuing advances in superconductors, which are now able to operate at liquid nitrogen temperatures, and of course semiconductor developments continue to transform the way in which equipment can be controlled.

Finally, in this opening group there is a chapter on measurement and instrumentation. Modern equipment and processes rely increasingly on sensors and instrumentation for control and for condition assessment and diagnostics, so in this chapter there are some changes in coverage, the emphasis now being on sensors and the way in which signals from sensors may be processed.

The next group of eight chapters form the core of the book and they cover the essential groups of electrical equipment found today in commerce and industry.

The opening five chapters here cover generators, transformers, switchgear, fuses and wires and cables. These are the main technologies for the *production and handling* of electrical power, from generation, transmission and distribution at high voltages and high powers down to the voltages found in factories, commercial premises and households. Exciting developments include the advances made in high-voltage switchgear using $SF_6$ as an insulating and arc-extinguishing medium, the extension of polymer insulation into high-voltage cables and the continuing compaction of miniature and moulded-case circuit breakers. A new section in the wires and cables chapter addresses the growing technology of optical fibre cables. Although the main use for this technology is in telecommunications, which is outside the scope of the book, a chapter on wires and cables would not be complete without it and optical fibres have in any case found a growing number of applications in electrical engineering.

The following four chapters describe different groups of equipment which *use or store* electrical energy. Probably the most important here is electric motors and drives, since these use almost two-thirds of all electrical energy generated. Power electronics is of growing importance not only in the conversion and conditioning of power, most notably in variable-speed motor drives, but also in static power supplies such as emergency standby, and in high-voltage applications in power systems. The range of batteries now available for a variety of applications is extensive and a chapter is set aside for this, including the techniques for battery charging and the emerging and related technology of fuel cells. If fuel cells fulfil their promise and start to play a greater part in the generation of electricity in the future then we can expect to see this area grow, perhaps influencing the generator and power systems chapters in future editions of the handbook.

The final group of four chapters covers subjects which embrace a range of technologies and equipment. There is a chapter on power systems which describes the way in which generators, switchgear, transformers, lines and cables are connected and controlled to transmit and distribute our electrical energy. The privatization of electricity supply in countries across the world continues to bring great changes in the way the power systems are operated, and these are touched upon here, as is the growing impact of distributed generation. The second chapter in this group covers the connected subjects of electromagnetic compatibility and power quality. With the growing number of electronically controlled equipment in use today, it is imperative that precautions are taken to prevent interference and it is also important to understand the issues which are raised by the resulting disturbances in power supply, such as harmonics, unbalance, dips and sags. The next chapter describes the certification and use of equipment for operation in hazardous and explosive environments; this covers a wide range of equipment and several different classes of protection. And finally, but perhaps most importantly, a chapter on health and safety has been added for this edition; this issue rightly pervades

most areas of the use of electrical power and this topic is a valuable addition to the handbook.

In most chapters there is a closing section on standards, which influence all aspects of design, specification, procurement and operation of the equipment. At the highest level are the recommendations published by the International Electrotechnical Commission (IEC), which are performance standards, but they are not mandatory unless referred to in a contract. Regional standards in Europe are Euro-Norms (ENs) or Harmonized Documents (HDs) published by the European Committee for Electrotechnical Standardization (CENELEC). CENELEC standards are part of European law and ENs must be transposed into national standards and no national standard may conflict with an HD. Many ENs and HDs are based on IEC recommendations, but some have been specifically prepared to match European legislation requirements such as EU Directives. National standards in the UK are published by the British Standards Institution (BSI). BSI standards are generally identical to IEC or CENELEC standards, but some of them address issues not covered by IEC or CENELEC. In North America, the main regional standards are published by the American National Standards Institute (ANSI) in conjunction with the Institute of Electrical and Electronics Engineers (IEEE). The ANSI/IEEE standards are generally different from IEC recommendations, but the two are becoming closer as a result of international harmonization following GATT treaties on international trade. Coverage of all these groups is attempted in the tables listing the key standards.