THE KEY TO TECHNICAL TRANSLATION

Volume 1
Concept specification

MICHAEL HANN

JOHN BENJAMINS PUBLISHING COMPANY

THE KEY TO TECHNICAL TRANSLATION I

THE KEY TO TECHNICAL TRANSLATION

VOLUME ONE

CONCEPT SPECIFICATION

by

MICHAEL HANN

JOHN BENJAMINS PUBLISHING COMPANY
AMSTERDAM/PHILADELPHIA

1992

Library of Congress Cataloging-in-Publication Data

Hann, Michael.
The key to technical translation / by Michael Hann.
p. cm.
Includes bibliographical references and indexes.
Contents: v. 1. Concept specification -- v. 2. Terminology/lexicography.
1. Technology--Translation into English. 2. Translating and interpreting. I. Title.
T11.5.H36 1992
428'.02'0246--dc20 92-23779
ISBN 1-55619-471-4 (set hb)/1-55619-472-2 (set pb) (US alk. paper) CIP
1-55619-467-6 (hb vol.1)/1-55619-468-4 (pb vol.1) (US alk. paper)
1-55619-469-2 (hb vol.2)/1-55619-470-6 (pb vol.2) (US) alk. paper)
ISBN 90 272 2122 7 (set hb)/90 272 2123 5 (set pb) (Eur alk. paper)
90 272 2118 9 (hb vol.1)/90 272 2119 7 (pb vol.1) (Eur alk. paper)
90 272 2120 0 (hb vol.2)/90 272 2121 9 (pb vol.2) (Eur alk. paper)

John Benjamins Publishing Co. · P.O. Box 75577 · 1070 AN Amsterdam · The Netherlands
John Benjamins North America · 821 Bethlehem Pike · Philadelphia, PA 19118 · USA

ACKNOWLEDGEMENTS

My thanks for assistance in the publication of this manuscript are due above all to my friend and former boss Professor Juan C Sager of the University of Manchester (UMIST). Grateful thanks are due to the British Department of Education and Science for a research fellowship in the mid seventies, which enabled me to acquire the programming and other skills necessary for this book. Thanks for many helpful comments and improvements are also due to Dr Paul Foster of the Johannes-Gutenberg Universität (FAS), to Messrs Richard Schneider and Jürgen Herber for their invaluable help in producing a camera-ready disk version of the book, and to Frau Ingrid Helbing of the German Nuclear Research Centre (KfK) for assistance in proof-reading.

Apologies are due to the many ladies reading this book for my insistence on referring to the translator everywhere as "he" and to anyone with a phobia about *capital letters* in English. Engineering fields such as Electronics, Automobile Ignition or Chemical Engineering are capitalised throughout. Occasionally this makes the odd English sentence look more like German, but on the whole it avoids repetition and ambiguity. In the case of technical acronyms such as *fet*, *mosfet*, *ac/dc*, *CAD*, *RAM*, the use or non-use of capitals depends upon what is more usual in the respective field rather than any linguistic conventions.

Note: The standard symbols Ω, Å, μ, μF, μA, α-/β-/γ-, in the contexts *ohm, angstrom, micron, microfarad, microamp, alpha/beta/gamma radiation*, have been avoided in the manuscript to simplify editing processes.

PREFACE

Volume 1 presents a systematic introduction to the basic concepts underlying all areas of modern science and technology, with regard to the problems involved in translating from German into English. English technical terms originating from general language (e.g. *stress*, *strain*, *tension*) or those commonly misunderstood by translators (such as *Kapazität*: *capacity*, *capacitance*, *capacitor*) are defined clearly, using simple examples without mathematics. Even those linguists with no experience of technology or technical translation can acquire an important basic understanding of areas such as Physics, Chemistry, Semiconductors, Computers, Electronics, Materials Science, Machine Technology, Automobiles, Electrical Engineering and Nuclear Technology.

Volume 2 is a practical handbook for translators and consists of several bilingual glossaries. The book has some particularly interesting lexicographical features, including: the "Collocation Dictionary" - a glossary of general nouns, adjectives and verbs used in different technical contexts, and the "Polyseme Dictionary" which, among other things, highlights and distinguishes German polysemes, such as:

Gehäuse:	case, casing, housing, boss, chamber
Rolle:	roll, reel, castor, pulley
Netz:	net, network, mains, gauze

A further feature of the book is the bilingual "Technical Thesaurus" which supplements the information of Volume 1. The thesaurus entries are defined in terms of one another using hierarchic/semantic relations.

The book is mainly intended for German/English technical translators (both directions) - professional, free-lance translators and interpreters, language students and university teachers. It will also interest the following groups:

i) technical translators from other languages into English (Volume 1);

ii) German-speaking technologists and scientists requiring a sound basic knowledge of technical English;

iii) readers interested in applications of the methods of General Linguistics (Semantics, etc) to technical language;

iv) computer scientists involved in the design of software for lexicographical applications.

VORWORT

Band 1 stellt eine systematische Einleitung in die Grundbegriffe aller Gebiete der modernen Wissenschaft und Technik im Hinblick auf Probleme der Fachübersetzung aus dem Deutschen ins Englische dar. Englische Fachtermini, die aus der Gemeinsprache stammen (z.B. *stress*, *strain*, *tension*) oder solche, die von Übersetzern häufig falsch verstanden werden (z.B. *Kapazität*: *capacity*, *capacitance*, *capacitor*), werden durch einfache Beispiele ohne Mathematik klar definiert. Das Buch vermittelt auch Lesern, die keine technischen bzw fachsprachlichen Erfahrungen besitzen, wichtige Grundkenntnisse aus Fachgebieten wie Physik, Chemie, Halbleiter- bzw Computertechnik, Elektronik, Werkstoffswissenschaften, Maschinenbau, Automobil-, Elektro- und Kerntechnik.

Band 2 ist ein Handbuch für die Fachübersetzungspraxis. Er besteht aus zweisprachigen Fachglossaren. Besonders interessant vom lexikographischen Gesichtspunkt sind das sogenannte "Collocation Dictionary", d.h. ein Glossar von gemeinsprachlichen Substantiven, Adjektiven und Verben in verschiedenen technischen Zusammenhängen, und das "Polyseme Dictionary", das auf die Mehrdeutigkeit von Wörtern wie

Gehäuse:	case, casing, housing, boss, chamber
Rolle:	roll, reel, castor, pulley
Netz:	net, network, mains, gauze

aufmerksam macht. Der zweisprachige "Technical Thesaurus" ist ein weiteres Merkmal dieses Buches und ergänzt die Informationen vom Band 1. Die Einträge im Thesaurus werden durch eine Gegenüberstellung hierarchischer bzw semantischer Beziehungen definiert.

In erste Linie ist das Buch für Fachübersetzer Deutsch/Englisch (beide Richtungen) gedacht, sowie für Dolmetscher, Sprachdozenten und Studenten. Es dürfte aber auch folgende Gruppen interessieren:

i) Fachübersetzer, die aus anderen Sprachen ins Englische übersetzen;

ii) Ingenieure, Techniker und Naturwissenschaftler, die ihre Kenntnisse der englischen Grundfachsprache erweitern wollen;

iii) Sprachwissenschaftler, die sich für Anwendungen der Methoden der allgemeinen Linguistik (insbesondere der Semantik) auf die Fachsprachen interessieren;

iv) Informatiker, die Software für lexikographische Anwendungen herstellen.

CONTENTS

CONTENTS of VOLUME TWO

INTRODUCTION

Many people will remember being obliged at some point in their school life to specialise in either *Language* or *Science* subjects, with a particular career direction in mind. At least one career, however, demands a sound basic knowledge of both areas - that of *technical translator*. Regretably, good linguists with the background for understanding the vast spectrum of engineering subjects are rare. It may be acceptable for a literature translator to remain oblivious of the simplest technical concepts throughout his or her working life, but a technical translator cannot afford to ignore the industrial world, even though his general education has done so. This book helps to bridge certain gaps in the standard education of linguists by providing a neat summary of the basic concepts and terminology common to all major areas of technology, ranging from Chemistry to Computers, Automobiles to Aeroplanes, Bicycles to Nuclear Power.

Contrary to popular opinion, the job of a technical translator has little in common with other linguistic professions, such as literature translation, foreign correspondence or interpreting. Apart from an expert knowledge of both languages and a general awareness of popular literature and the current political scene, all that is required for the latter professions is a few general dictionaries, whereas a technical translator needs a whole library of specialised dictionaries, encyclopaedias and technical literature in both languages; he is more concerned with the exact meanings of terms than with stylistic considerations and his profession requires certain "detective" skills as well as linguistic and literary ones. Beginners in this profession have an especially hard time as there is currently no text-book covering the basic concepts of technology, which does not employ considerable Mathematics. This book attempts to meet this requirement.

Volume 1 provides an extensive basic terminology for technical translators into English, and draws attention to common pitfalls for both native and non-native English speakers. There are many examples illustrating problems in translation from *German*, and indeed each Chapter is followed by a brief bilingual glossary, but the book should also prove useful to translators from other industrial languages (French, Russian, etc). Its purpose is to enable linguists to acquire the basic skills of technical translation by themselves. Some 3000 fundamental technical English concepts are described, defined, or contrasted, together providing *keys* to the terminologies of all major fields of science and engineering.

Volume 2 consists of glossaries mainly intended for German translators, but it contains a sizeable *thesaurus* of technical English terminology and a dictionary of *collocations* useful for all translation into English. The objectives of Volume 2 are to expand the reader's command of technical vocabulary beyond the conceptual and terminological bases of Volume 1, and to limit potential error sources in the use of glossaries by virtue of an entirely new approach to dictionary organisation.

1 Layout

The book contains eleven main chapters and covers a selection of specialised fields whose underlying concepts constitute the basic vocabulary of all technologies. Each chapter deals with a separate engineering field but draws upon the terminology of previous Chapters, paying particular attention to problems of term selection in practical translation, especially where one German term covers several related but non-identical English concepts (polysemy). The following polysemous German terms illustrate typical problems encountered by beginners in technical translation, which are resolved by reading the appropriate Chapters.

Spannung:	voltage; potential; emf; stress; tension.
Spule:	inductor; choke; coil; winding.
Widerstand:	resistor; resistance; reactance; impedance.

Bindungskräfte:	binding forces; bonding forces.
Leitfähigkeit:	conductance; conductivity.
Zeichen:	character; digit; mark; sign; symbol.

Chapter 1 introduces certain fundamental distinctions, initially from the field of Physics but now employed throughout engineering, for the definition of *parameters* or more precisely *physical quantities*. It concentrates upon *mechanical* concepts, such as *power*, *momentum*, *velocity* and *torque*, and prepares the ground for the *electrical* concepts of Chapter 2: *resistivity*, *charge*, *inductance*, *reactance*, *impedance*, *phasors*, etc, the basis of Electrical Engineering, Electronics, Computing and other major industries. Chapter 3 introduces the field of Materials Science, concentrating upon those aspects of Atomic and Molecular Physics which underlie the main branches of engineering. This completes the theoretical basis of technology, many aspects of which were formulated centuries ago by great scientists such as Newton, Ampere, Faraday, Maxwell and Kelvin, but regretably still delude linguists in general.

Chapters 4-11 cover specific technologies, including: Nuclear, Electronic, Mechanical, Automotive, Civil, Chemical and Computer Engineering. Each chapter deals with the basic terminology of a particular field, much of which is common to other fields and reappears in later chapters. Chapters 4-7 should be read consecutively, but the order of the final chapters is not critical. On completing this book the reader should have acquired a technical vocabulary equivalent approximately to that of a first-year undergraduate engineering student.

Important concepts like *tension*, *stress*, *strain*, which are frequently confused and mistranslated by linguists with limited technical background, are defined explicitly. Those difficult to visualise, such as *potential*, *reactance*, *phase*, are described by analogy with everyday situations. Concepts concerning concrete objects - *master cylinder*, *pn-junction*, *particle accelerator*, are described in context, so that the reader relates newly acquired terminology to other terms in the field immediately from the outset. Each chapter is followed by a brief, bilingual (English/German) glossary of the main vocabulary concerned, a so-called *Term List*. Many of the Term Lists contain additional information by virtue of their systematic structure. This is explained in the next main section, headed *Access Guide*.

The book contains a so-called *Global Index*, enabling rapid access to technical terms in the chapters, and there is a Chapter 12, which discusses the Term Lists, the Global Index and the glossaries of Volume 2 from a lexicographical viewpoint. The final Appendix illustrates some problems in translation, solved by appropriate use of the reference glossaries in both volumes. The second volume makes an ideal companion to this book, both for German speakers wishing to acquire a rapid grasp of English engineering terms, and for English translators needing a command of technical German.

Those linguists interested in technical terminology for academic rather than translation purposes are recommended to consult the Appendix, where they will find some interesting practical applications of *General Linguistics* (homonymy, polysemy, polyonymy, etc). Other examples can be "discovered" in the glossaries by employing similar methods.

Finally, for readers who feel a little overwhelmed by the immediate use of advanced lexicographical techniques in an introductory book on translation, there is an alphabetic list of technical vocabulary in English and German, the Term Index.

2 Objectives

The objective of this book is to present an efficient, systematic method of learning the skills of technical translation, an alternative to the current haphazard approach of many academic and other institutions which confront the learner with unstructured material and allow him to flounder. The current approach does little to alter the present situation that the best technical translators are either self-taught or have studied another subject besides language which gives them their advantage. Those university teachers who prefer using texts from areas such as *motor-car maintenance* or *personal computers* do little justice to the subject of technical translation since these areas, although specialised, are only one step removed from general language. Nobody can be expected to translate anything he does not understand, but many professional free-lance technical translators spend their lives doing just that.

Ironically, the main source of error in translation is not highly obscure terminology relating to complex engineering objects. These terms may not occur in dictionaries but they do appear in the technical literature itself: the translator only has to find two similar source texts, one in each language, and locate the same diagram or description of the object in both texts, to determine the translational equivalent. His main error source usually concerns concepts which *cannot* be seen - such as

Kraft:	force, action, tension, thrust
Leistung:	power, performance, wattage, dissipation
Impuls:	impulse, pulse, momentum

Such technical terms have a precise significance in Mathematics or Physics, and hence Engineering, but originate from general vocabulary. Too many professional translators are blissfully unaware of the polysemous nature of these terms and make little attempt to determine the true English equivalent in the given context.

This volume takes the bull by the horns and introduces these "invisible" but fundamental concepts, many of which originate from school Physics and Chemistry, in the opening chapters. Subsequent chapters and *Term Lists* develop the translator's overall command of engineering terminology, together with his understanding of specific fields, and Volume 2 enables him to reduce two further sources of translational error: *term specification* and *general vocabulary*.

Apart from a selection of graded practice texts the reader now has what he needs to *teach himself* the skills of technical translation. Indeed, the systematic layout of the two volumes provides not just an excellent handbook for professionals, but a firm basis for the teaching of Technical Translation at universities and other academic institutions.

ACCESS GUIDE

At various stages in this book the reader may desire rapid access to definitions and descriptions of English terminology covered in previous chapters. He may also require German equivalents. The following sections discuss different approaches to translation and dictionary access, and introduce the glossaries of this volume: the Global and Term Indexes and the Term Lists. The final section concerns the subject of Information Retrieval and its application to Lexicography.

1 Translation Approaches

Some translators buy scores of dictionaries, and repeatedly access the same term in different lists in the hope that the foreign term occurring most frequently is the correct one. Others use dictionaries very little, preferring to obtain first-hand information from encyclopaedias and identify concepts in the two languages directly. A third type of translator purchases standard textbooks on various subject fields in both languages, and makes extensive use of the respective indexes to obtain collocations of equivalent terms. This approach of examining terms and concepts *in context* is recommended for teachers of translation.

The first translator, the "dictionary enthusiast" is the quickest, but by omitting the intermediate stage of *concept recognition* his translations are often misleading or even meaningless, when a frequent term is wrongly rendered. The "encyclopaedia devotee" is generally more accurate, but he may still have a tendency to render general terms wrongly, for instance *gebunden* as *fixed* or *bound*, when the context (Materials Science) specifies *bonded*. It is the third translator who makes the best investment as regards speed and accuracy. He attempts to acquire a knowledge of the technical foreign language in the same way as his command of general language, and hopes eventually to translate more or less spontaneously. But the success of this method depends on the individual himself and his educational background. Many translators who try this approach fail to understand large areas of technical literature, even in their native language. The necessary *basic vocabulary* is lacking, especially where terms originate from fields, such as Mathematics, outside the area involved.

Finally there is a fourth type of translator, one who invariably employs at least two computers simultaneously, and invests in accessing systems and data banks rather than printed literature. This translator compensates for his lack of expertise in engineering by his skill in manipulating information systems. It is well known among this rapidly expanding group of translators that the alphabetic approach to dictionary structure is not always the best one. There are advantages in employing *reverse alphabetic lists* when identifying polysemes, hyponyms or synonyms, and hierarchic arrangements are preferable for the organisation of concepts. Detailed discussion of the computational lexicographical approach is deferred until Chapter 12.

This book combines the approaches mentioned, while encouraging translators to be as flexible as possible is switching from one technique to another. The result is neither dictionary, encyclopaedia, textbook nor data bank, but hopefully the optimum combination of all four. Volume 1 is a miniature textbook/encyclopaedia which attempts to provide the *conceptual basis* of all technology: the set of technical concepts which translators should understand before commencing an engineering or scientific translation. Volume 2 complements conventional dictionaries and data-base systems by highlighting *root terminological contrasts*, in the hope that by mastering these distinctions the potential translator will avoid the most common or most atrocious errors in *term selection*.

The accessing techniques described below will assist the reader at various stages in this volume. Other techniques, especially those for cross-referencing the glossaries of Volume 2, are discussed in Chapter 12 and illustrated with examples in the final Appendix; these are intended for proficient translators who have mastered both the technical and lexicographical aspects of Volume 1 and wish to understand other terminology present only in Volume 2.

2 Global Index

As might be expected, the book contains an index of technical concepts covered in the various chapters. Consider the following extract:

electron cloud 34
electron shell 31 422 F3C
electroplating 10.2

This implies that the term *electron cloud* appears in Chapter 3, section 4 (Section 3.4), *electron shell* in Sections 3.1 and 4.2.2, and *electroplating* in Section 10.2. The extract reveals that *electron shell* is included in a Term List designated *Figure 3C* (F3C), which leads to the German equivalent. The Global Index occasionally provides additional information, pertaining to the Collocation Dictionary (Volume 2). This is discussed in Chapter 12.

3 Diagrams, Term Lists

For convenience, *Diagrams* such as *The Periodic Table of Elements* (Fig.3A), *The Electromagnetic Spectrum* (Fig.4A) and *The Decay Transitions of Uranium-238* (Fig.4B) appear at the ends of the Chapters concerned (Chapters 3/4). So do the variety of *Term Lists*, most of which are bilingual (Eng./Ge.), one is even trilingual (Fig.8A - Br./Am./Ge.). Those arranged alphabetically contain additional information (such as *units*), useful even to readers not concerned with German. As the book progresses and the technical areas become more complex, the Term Lists become more informative. But also more sophisticated, giving way in many cases to *hierarchic arrangements*.

Consider the following extracts from Fig.5 - *Semiconductor Materials*:

3	crystal	141	charge carrier
32a	crystal structure	1411g	conduction electron
322a	crystal lattice	1412g	hole
3221p	lattice atom	1413m	mobility
32211g	impurity atom		

These arrangements reveal the following information about the concepts listed:

crystal lattice	associated with *crystal structure*;
lattice atom	part of a *crystal lattice*;
impurity atom	a type of *lattice atom;*
conduction electron	a type of *charge carrier*, the other type is *hole*;
mobility	a measurable parameter of a *charge carrier*.

The numerals indicate which pair of terms is related; the symbols or rather *descriptors* - *a, p, g, m* reveal the kind of relation - *associative, partitive, generic, metric*, and correspond to the definitions: "associated with", "part of", "type of", "measurable parameter of".

Despite the apparent complexity at first sight, of some of the larger terminological hierarchies (Fig.6A-E, 7A-C, 8B-E) this is merely an alternative representation of the common *family tree* structure used by genealogists to reveal lineages of ancestral heritage. It is also employed by biologists to indicate taxonomic relationships among plants, creatures and organisms, by library workers classifying and arranging books, and above all by *information scientists* and *software writers* dealing with data-management schemes requiring fast retrieval and compact storage.

The author and indeed the publisher had slight misgivings about applying hierarchical classification to engineering terminology, wondering whether linguists are ready for this. Nevertheless, this book could mark the beginning of an era of "perestroika" among linguists and literature translators, tearing down the iron curtain separating them from the outside world of science and technology. Just as previous generations of translators developed typing and clerical skills in the course of their profession, so the next generation will undoubtedly become excellent amateur computer programmers, who are quite familiar with hierarchic representations and appreciate the structures given as a powerful means of classifying, disseminating and memorising terminological information.

4 Term Index

Some readers may prefer to concentrate on the *engineering* aspects of this book, and investigate the dictionary structures at a later stage. For the benefit of these people, especially German native-speakers, there is a bilingual *Term Index* at the end of this volume, which gives German interpretations of the English technical vocabulary employed in the Chapters.

Root terms are present in the Index, but not all compounds are included. Just representative samples, such as *power (Leistung), power transistor (Leistungstransistor), power stage (Leistungsstufe)*, and expressions which give readers a feeling for potential difficulties in translation: *power supply (Stromversorgung), power cord (Netzkabel), power dissipation (Wärmeabgabe)*. Trivial compounds - *industrial diamond, user program, machine language,* are excluded; so are terms like *fuse-box, breadboard, silencer* which hardly exist in German and need to be understood rather than translated.

Most entries in the Index are *one-to-one* correspondences: *adjacent atom (Nachbaratom), alloy (Legierung), carbon (Kohlenstoff)*; but in some cases the German term implies a more restricted sense, that of the appropriate section in which it occurs, for example: *calculator (Taschenrechner), ion core (Atomrumpf), upward thrust (Auftrieb)*. Other translations may be appropriate in slightly different contexts (e.g. *Tischrechner*). Problems occur for the user where a term such as *work* has the same German equivalent (*Arbeit*) virtually throughout technology, except in a narrow sense in one small area: *work* from the area Machine Technology meaning *component being worked (Werkstück)*.

The Term Index is merely a list of technical vocabulary useful for quick reference when reading the Chapters. Used in isolation it has the features of a poor bilingual dictionary in that *subject field, context, usage* and above all *concept specification* are ignored, and contrasts sharply with the *Polyseme*

Dictionary, Thesaurus and other dictionaries of Volume 2. Used in conjunction with the Global Index, however, many of these problems are overcome. Readers who can cope with new conceptions in *Engineering* and *Lexicography* simultaneously are recommended to consult the *Term Lists* for German terms, or to use the Dictionaries of Volume 2 from the outset. The Term Index is to be treated as a subsection of the Global Index, and is not mentioned again in isolation.

5 Information Retrieval

As an appropriate note on which to end this section, a short summary follows concerning techniques of information retrieval other than the simple *alphabetic search*, namely according to *reverse-alphabetic, morphological, contextual* and *conceptual* criteria. The discussion continues in Chapter 12, the Appendix, and Volume 2.

The oldest, most widely established system of dictionary organisation is the conventional *alphabetic* list. A modern, computational variation of this is the *reverse list*, where entries are sorted in alphabetical order from the ends of the words rather than from the beginning. For instance:

electronic switch
toggle switch
on/off switch
light switch

Thus all dictionary entries ending in *switch* are listed adjacently. Another alternative is the *morphological list*, where terms containing the same *root morpheme* are arranged together. Thus

electronic switch
on/off switch
piezo-electric switching module
switch
switching component

toggle switch

It is just a small step from a morphological retrieval system to a *contextual* or *collocational* one, where the computer locates *sentences* from previous texts containing *switch, piezo-electric, toggle, switching module, etc*. This system provides translators with *examples of usage*, a powerful aid in regard to term specification. Finally, the application of *contextual* retrieval methods to a *conceptually organised* data bank provides "definitions" like the following:

switch	a type of *electrical device* (Electrical Engineering)
switching module	a type of *circuit module* (Computer Technology)
ignition switch	part of an *ignition system* (Automobile Technology)
electronic switch	associated with *transistor, thyristor* (Electronics)
toggle switch	a type of *on/off switch* (Electrical Engineering)

The glossaries of this book employ all the above lexicographical arrangements:

Global Index	alphabetic
Polyseme Dictionary	alphabetic/reverse alphabetic
Thesaurus	conceptual
Collocation Dictionary	contextual
Term Lists	alphabetic, reverse, morphological, conceptual

A computer does not store terminology in any of the above arrangements. Oddly enough, the most efficient storage system is the *random* one, where the terms occupy storage cells in the original order in which they are entered. It then employs an elaborate labyrinth of *link addresses* to list the whole or part of the term bank in the lexicographical arrangement desired by the user. It would be possible to provide the reader with an labyrinth of address links to enable him to locate entries in hierarchic term lists or conceptual dictionaries. But unnecessary. Because unlike the computer, the reader can recognise *concepts*, and not just *terms*.

For example, suppose the German equivalent of *idling screw* is required. Knowing that the term originates from Automotive Engineering the reader scans the Contents list and locates Fig.8B - *Ignition, Carburation, Battery*. He then considers the hierarchies: *(1) ignition system, (2) fuel system (3) battery.* Examination of hierarchy *2* reveals the entries: *(24) carburettor, (246) adjuster screw,* and the desired term *(2461) idling screw* with its German equivalent *Leerlaufeinstellschraube*.

The Term Lists provide a convenient summary of the respective Chapter. In contrast to alphabetic glossaries, hierarchic term lists *oblige* the user to try to understand the *concept* behind the term accessed. If the reader finds it takes longer to locate entries in hierarchic lists than in alphabetic ones, it is possibly because he has not read the Chapter thoroughly enough.

Any readers still baffled by hierarchic systems could either consult Chapter 12, where other examples are given, or even ignore them on first reading. Similar *unstructured* information is obtainable in the Global Index, and in the Thesaurus (Volume 2).

Chapter One

PHYSICAL QUANTITIES

There are many everyday terms which are given a precise significance in elementary physics but are often not included or given misleading translations in dictionaries. A translator given a complex technical text to translate will often render the more obscure terms correctly but his translation may be meaningless because he does not realise that an apparently simple word like *Spannung* may imply *tension, stress* or *voltage* - three quite distinct concepts, within the same short text. Other simple examples are *laden*: load/charge; *Geschwindigkeit*: speed/velocity/rate; *Zeiger*: vector, phasor, indicator, needle. The various alternatives imply different concepts. Moreover, there are certain "false friends": the German *Impuls* is translated not by *impulse* but *pulse* in Electronics and *momentum* in Mechanical Engineering.

Weight, distance, volume, area, time, speed are examples of *physical quantities* whose significance is self-evident from the general meanings of these terms. *Work, power, charge, acceleration, momentum, force* are also everyday terms but a non-technical person may have difficulty in understanding the *exact* significance in a technical text. Definitions of these fundamental concepts follow. The reader is also introduced to the standard method of defining technical parameters, using concepts such as : *basic/derived quantity, unit/dimension, scalar/vector.*

To the technologist all the above concepts are so elementary that they rank alongside general language and he will have little patience with a translator who does not understand them. This Chapter is therefore intended for those translators who opted out of *physics* far too early in their schooldays and whose existence as technical translators has been in jeopardy ever since. Though relatively straightforward, this chapter should be studied quite closely as it provides a basis for concepts of far greater complexity in many other fields.

1.1 Basic/Derived Quantities

The basic *mechanical quantities* are *mass*, *length* and *time* often abbreviated to *M*, *L*, *T* where the latter refer to the so-called *dimensions*. A technologist would say that *mass* has the dimensions *M* or M^1 (spoken "M to the power 1"), *length* has dimensions L and time *T*. The terms *quantity* and *dimension* have different meanings here to the usual general language interpretations "amount" and "length/breadth/depth", which also occur in technical texts.

All other mechanical quantities - *speed, volume, acceleration, force, power*, etc are *derived quantities*, that is to say they are derived in terms of *basic quantities*: *speed* has dimensions LT^{-1} ;*volume* L^3; *acceleration* LT^{-2}; *force* MLT^{-2}, *power* ML^2T^{-3}.

1.1.1 Mass, Weight

In technology there is a sharp distinction between *mass* and *weight*. *Mass* is a *basic* physical quantity measured in the unit *kilogram* whereas *weight* is a *derived* quantity and concerns the *gravitational force* necessary to hold a *body* of a given *mass* on a given planet. Most of us are used to measuring our *weight* in *kg*, but in technology the unit is the *newton* since *weight* has the same dimensions as *force*, namely MLT^{-2}.

Example: an astronaut has a mass of 70 kg. On the earth's surface he weighs about 687 newton, on the moon considerably less than this and on Jupiter much more, even though his mass remains the same; indeed even on earth his weight will vary as the same individual will weigh more in the polar regions than at the equator, and more in a diving suit at the bottom of the Pacific Ocean than when climbing Mount Everest.

1.1.2 Work, Energy, Power

These are *derived* quantities with precise significance and dimensions: *energy* $M.L^2.T^{-2}$; power $M.L^2.T^{-3}$. *Work* has the same dimensions as energy and consequently the same unit, the joule.

In the case of SI-units (Systeme Internationale) the basic quantities mass, length and time have units *kilogram* (kg), *metre* (m) and *second* (s) respectively. Algebraic equations involving for instance *velocity* or *volume* will yield answers in terms of *metre/second* (ms^{-1}) or cubic metres (m^3). If velocity is required in kilometres/hour or volume in litres this entails a simple arithmetical calculation on the part of the technologist and is not normally expected of the translator. The *basic* unit of energy, namely: $kg.m^2.s^{-2}$ is too clumsy for everyday use and the term *joule* is substituted instead.

Work is defined as *stored energy*. For instance if a cart weighing 100 kg is pulled to the top of a hill 100 m high the work done by the horse is about 100 000 joule. This figure equals the so-called *potential energy* of the cart and provides a measure of the *kinetic energy* which the cart will attain if, after disconnecting the horse, it is allowed to roll down the hill again. The concept *potential* is used in an analogous manner in *electrical* contexts, where it is a contextual synonym of *voltage* (section 2.1).

Power is defined as the rate at which work is done or energy is stored, the obvious unit *joule/second* being replaced by the SI term *watt*. This quantity occurs in *electrical* contexts too but is defined in terms of *voltage* and *current*; the same unit *watt* is also used. Indeed the concepts *energy* and *power* and the units *joule* and *watt* are common to all branches of science and technology.

1.1.3 Coulomb, Kelvin, Candela, Mol

For all other areas of technology the number of basic quantities needed in addition to *mass*, *length*, *time* in order to define specifically the many hundreds of derived concepts is restricted to just four: *electric charge* (unit: coulomb or ampere-second), *temperature* (kelvin), *luminous intensity* (candela) and *mole* (mol).

The *degrees* of the Kelvin temperature scale are the same as those of Celsius used in everyday weather reports but the Kelvin scale starts at a much lower temperature, equivalent roughly to the freezing point of hydrogen *-273 C*; this corresponds to the *zero energy state* of all substances, atoms or atomic particles in the universe.

The unit of light intensity, the *candela* is rarely encountered by technical translators except in specific texts concerning say Optics or Astronomy. *Mol* is encountered in Materials Science, Chemistry and Nuclear Technology and concerns the *Avogadro Constant*, which provides the number of *molecules* in a certain *mass* of material (1 *gram-molecule*). Due to the fact that *matter* consists of *atoms* which in turn consist of *elementary particles* of fixed mass -*protons*, *neutrons* and *electrons*, the *Constant* postulated by the early scientist Avogadro is indeed a *constant* of all matter and indirectly underlies all *chemical equations*.

The remaining basic physical quantity, *electric charge* is encountered in many different contexts throughout this book. It is defined in section 2.1.

1.2 Scalar/Vector Quantities

A can contains 1 litre of petrol. If 1 litre more is added it will contain 2 litres. It does not matter whether the additional litre is poured in through the spout at the top, through a hole in the side of the can or if it is pumped in through the bottom, the can will still contain exactly 2 litres. *Litre* is a measure of *volume* which is a *scalar quantity*.

Energy is also a scalar quantity. A skier at the top of a mountain may have a *potential energy* of 70 000 joule. It is immaterial which route he took to reach the top; the total amount of *physical* work which he (or the ski-lift) has had to exert still amounts to 70 000 joule. (Energy and work have the same *dimensions*.) When he skis to the bottom all this energy is converted into *kinetic energy* (the energy of motion) and eventually into *heat* and *sound* when he brakes. Whether he has skied slowly and elegantly, rolled headlong or even done a ski-jump into soft snow is immaterial. On reaching the bottom he has used 70 000 joule of energy.

Energy in the general language usually implies *biological energy* which is also measured in *joule*, although the older unit *calorie* still occurs (the latter being a now obsolete measure of *heat*). The biological energy loss of the skier, which gives a measure of his subsequent *appetite* in the restaurant, is irrelevant in the above example.

In technical texts one speaks of the *conservation of energy*, meaning that energy is not really "lost" (even though the term *energy loss* is used) but converted into other forms, for instance *potential* into *kinetic energy*, *electrical energy* into *heat*. "Energy losses" due to *friction*, *sound*, etc are relevant in the skier example too but are minimal.

Force is not a scalar quantity but a vector one. School experiments involving masses suspended by cords over *frictionless pulleys* rapidly lead to the conclusion that two forces each of 1 newton do not necessarily result in a combined force of 2 newton; it depends on how they are combined; it is often much less than the maximum value of 2 newton and may even be zero. When combining forces, geometric techniques such as the *parallelogram of forces*, or algebraic methods (*vector addition*) are employed.

Other vector quantities are *velocity*, *acceleration*, *momentum*, all of which concern objects in motion. Rotating bodies are characterised by the concepts: *angular velocity*, *angular acceleration*, *angular momentum*, which are also vector quantities and involve distinctions such as *clockwise/anticlockwise* (Am. *counter-clockwise*).

Vectors also represent the instantaneous motion of the particular particles (hypothetical or concrete) constituting *sound* waves, *light*, *radio* waves, *microwaves* and other periodic oscillations. The mathematical techniques are often quite complex. Moreover, in Electrical and Electronic Engineering it is convenient to describe *alternating voltages* and *currents* by vectors in order to combine them. It should be noted, however, that the term *vector* itself is not normally used here; for pragmatic reasons *phasor* is preferred (section 2.7).

1.3 Magnitude, Direction

Fig.1 and Fig.2A contain lists of the main *mechanical* and *electrical quantities* encountered in technology. Familiarity with these quantities, and a knowledge of which are *scalar* concepts and which *vector* is strongly advisable for technical translators, in order to avoid elementary misunderstandings.

Scalar quantities are *specified* by numbers and units: 4 kg, 50 watt, 100 newton, 23 ohm - namely simple statements of *magnitude*. *Vector* and *phasor* quantities require two parameters: *magnitude* and *direction*. In Fig.1, the list of scalar and vector quantities, commonly encountered in mechanical systems, the *units* refer to the *magnitudes* of the quantity concerned. *Direction* is specified by means of an angle in a two- or three-dimensional co-ordinate system. Thus, one might speak of: a *force* of magnitude 50 newton acting at an angle of 40 degrees to the surface; an *angular velocity* of 5 radian/sec in a clockwise direction; an *acceleration* of 5g vertically downwards.

Note: In fields such as Aeronautical Engineering the basic unit of acceleration ms^{-2} is substituted by a value equivalent to that of the earth's gravity *g* (about 9.87 ms^{-2}). Thus an acceleration of 5g means five times that of gravity. (Technologists do not confuse *5g* with *5 gram*.)

Most of the electrical quantities of Fig.2A are *scalars*, including *current* and *voltage* in *dc* (direct current) contexts. The distinction *scalar/vector* is not so relevant here. But in *ac* (alternating current) contexts it is important to realise that *currents* and *voltages* are regarded as *phasor quantities* (vectors in the *frequency domain*). Their specification also requires a kind of "direction", so-called *phase*. For instance one might speak of: a *voltage* of magnitude 20 volt with *phase angle* 45 degree; a *current* of 5 amp with a *phase lead* of 10 radian; a *voltage* with a *phase lag* of 85 degree. Electrical quantities are discussed in more detail in Chapter 2.

1.4 Mechanical Quantities

Though propounded more than three centuries ago, the ideas of the great physicist Sir Isaac Newton still form the basis of Mechanical Engineering and many other areas, including Vehicle Technology, Construction Engineering and Aeronautics. They are also applied in many areas of Physics, but here Newtonian Mechanics has been largely replaced by the more recent *Quantum Mechanics* in connection with *elementary particles* (atoms, molecules, electrons, etc) and by Albert Einstein's theory of *General Relativity* with regard to *bodies* moving at very high speeds. Quantum Mechanics is widely applied in Materials Science (Chapter 3), including *semiconductor materials* (Chapter 5); *General Relativity* is used in Astronomy and in Nucleonics (Chapter 4).

Newton showed that there is no physical difference between *gravity* - which causes objects to fall to the ground, and *gravitation* - responsible for the mutual attraction of celestial bodies (planets, stars, meteors, etc). Nevertheless, the linguistic distinction still exists.

1.4.1 Speed, Velocity, Acceleration

Speed is a scalar quantity; *velocity* a vector one. In the strict sense *speed* is regarded as the *magnitude* of a *velocity vector*, but in practice the two terms are often synonymous. For instance *velocity of light* and *speed of light* are equally common. Nevertheless, in contexts concerning rotational movement such as *machinery*, there is a distinction: when a satellite rotates around the earth its *speed* remains constant but its velocity changes all the time due to the changing direction of its motion. Hence the terms *rotational speed* and *rotational velocity* are not synonymous.

Whether *Geschwindigkeit* is rendered as *speed* or *velocity* in particular fields often seems arbitrary to translators. Generally speaking the term *velocity* occurs more often in *scientific* than in *engineering* texts, for instance: *neutron velocity* (Nuclear Technology), *engine speed*, *vehicle speed* (Automobile Technology). The correct alternative depends on the subject matter, but *speed* is often a stylistical alternative to *velocity* in texts where the distinction *scalar/vector* is not critical.

Speed and *velocity* have the same dimensions (ML^{-1}) and the same units (m/s; km/h; mph). *Acceleration* is defined as the *rate of change of speed* or of *velocity*. The same term covers both the scalar and the vector quantity.

One can of course speak of the *rate of change of acceleration*, but only mathematical symbols, not terms designate such quantities.

1.4.2 Power, Performance, Efficiency

These terms correspond to the German *Leistung* in specific contexts and are a frequent source of confusion for beginners in technical translation. The problem is easily resolved.

In most cases *Leistung* concerns the rate of production, dissipation, storage or release of energy. The form of energy may vary considerably: heat, electricity, magnetism, sound, light, mechanical energy, radioactivity or chemical energy; but it can be taken as rough general rule that if *Leistung* concerns a *parameter* measured in the basic unit *watt* then it is translated as *power*. But there are exceptions, where correct choice is largely a matter of familiarity with the subject field:

Motorleistung (Automobiles)	*engine performance*
Bremsleistung (Automobiles)	*braking efficiency*
Wärmeleistung (Electronics)	*thermal dissipation*

Efficiency in contexts such as *machinery*, *electric power*, *steam engines*, usually designates the ratio of the *power* put into the device - the *machine*, *transformer*, or *engine*, to that got out; it is expressed as a percentage. Such texts involve the conversion of energy from one form into another, such as *heat* into *mechanical energy*. The German equivalent is *Wirkungsgrad*.

Performance is a general term often used rather loosely by the automobile industry to describe how a vehicle "performs" under extreme conditions. It usually implies the maximum *horsepower* developed by the engine (strictly speaking *brake horsepower*, the power required to *brake* the engine in a laboratory) but can include other parameters, such as *maximum engine torque*, *maximum cruising speed* or even *minimum fuel* consumption.

1.4.3 Impulse, Momentum

When one body collides with another the general terms *impact* and *collision* describe the event. One speaks of the *impacts* of *gas molecules* on the *walls* of a *vessel* but of *collisions* between *gas molecules*. The terms are close and the verb *collide* applies in both cases (compare also the German *Stoß* and *Zusammenstoß*). In the following description the term *collision* is interchangeable throughout with *impact.*

Impulse and *momentum* are defined physical quantities used in predicting the results of a collision. *Impulse* is calculated by multiplying the (very large) *instantaneous force* acting between the bodies at the moment of collision with the *duration* of the collision (a very short instant). Multiplication of this *large* quantity with an *infinitessimal* one results in the *finite* entity *impulse*. This is numerically but not conceptually equal to the *momentum*; the latter is defined as the total of the products *mass times velocity* for each object involved in the collision.

Regretably a mistake in translation was made possibly hundreds of years ago so that the German *Impuls* corresponds not to *impulse* but to *momentum*. *Momentum* is a frequent concept in technical English and is used in areas as different as *vehicle-testing* (Automobile Technology), *charge carrier motion* (Semiconductors), *Thermodynamics* (behaviour of gases) and *Nucleonics* (elementary particles). It should *not* be confused with *impulse*, which is a theoretical concept occurring rarely and with a different significance.

1.4.4 Stress, Strain, Tension

The terms *stress*, *strain*, *tension* are a frequent source of confusion, because in general English all three correspond to the German *Spannung*. The technical terms designate unique concepts in Basic Mechanics and are important particularly in areas such as Mechanical or Civil Engineering (Chapter 9).

Tension is the *force* existing at any point in a body when it is being *extended* or *elongated* in one direction. For instance when an object is suspended from a *coil spring* the spring is extended by the *weight* of the object attached. The *reaction* (Newton's Law) to this *weight* applied at the end of the spring is a *tensile force* (syn. *tension*) in the spring itself. When the object is placed on top of the spring the latter is *compressed*, that is subjected to a *compressive force* (syn. *compression*). The same terminology and physical laws apply when instead of a spring, an elastic band is used, or in fact any other body, including so-called *rigid bars/rods* used in *machinery*. Indeed, the *members* of a bridge, roof or other support structure are distinguished by engineers according to whether they are subjected to *tension* or *compression*. Outwardly they may be indistinguishable, but the civil engineer refers to those members under tension as *ties* and those under compression as *struts*. *Tension*, *compression*, *action*, *reaction*, *weight* are all *forces*.

Tension or *compression* correspond to the total internal force acting at any point in an object *extended/compressed* in *two dimensions*. Many objects are extended or compressed three dimensionally: they are *stressed*. The physical concept *stress* refers to the *force* per *unit area* at any point in a body or material. *Stresses* give rise to *strains*, where the latter corresponds to the *proportional elongation* of the stressed body. *Stress* has the same *dimensions* as *pressure*, whereas *strain* is a *dimensionless quantity*.

If units appear in the text the translator should have no difficulty in distinguishing *tension*, *stress*, *strain*. *Tension* is measured in *newton*, *stress* in *newton/m*^{2} and *strain* has no units. Problems occur in less easily defined expressions, such as: *axle strain* (Vehicles), *surface tension* (Liquids), *shear stress*, *thermal stresses* (Materials).

Note: The term *electrical tension* (Spannung) is virtually obsolete. It was replaced by *voltage* throughout science and technology about sixty years ago. It occurs only in restricted areas as a type of "linguistic fossil", for instance *LT-circuit* (low-tension circuit, Automobile Ignition).

1.4.5 Moment, Torque, Torsion

When a heavy army tank drives over a bridge the bridge itself tends to sag slightly according to the position of the tank. The product of the *weight* of the tank and its *distance* from the nearest bridge support corresponds to the *moment* of the *force* about the given *point*. The *moment*, in this case the *bending moment* of the bridge should be compatible with the maximum *shear strength* of the bridge girders. Otherwise the bridge will break. School physics teachers encourage children to carry out simple experiments involving the calculation of *moments* in order to convey the concept of *static equilibrium*.

Motorists who persistently grip their *steering wheel* near the centre or have fitted a smaller (more elegant) steering wheel, invariably have trouble on icy roads. The same *force* applied to the edge of a large wheel is more effective than applied to a small wheel, since the former involves a larger *torque*. *Torque* has the same dimensions as *moment* and is defined as the product of the *force* applied and the *radial distance*. In the context of *leverage*, such as the bridge example above, the German *Drehmoment* is rendered in English as *moment*, whereas if the context involves *rotation* (steering wheel, shaft, axle, etc) the correct term is *torque*.

In a simple motor vehicle the engine develops a *torque* which is transmitted to the *drive shafts* which turn the road wheels. If the vehicle is *jacked up*, so that the wheels are off the ground, *friction* is negligible. However, when the vehicle is moving the wheels are subject to *road friction* which subjects the shafts to a "twisting" force, termed *torsion*. *Torsional stresses* are exerted on the shaft and must be compatible with the *torsional shear strength* of the material, especially when the vehicle is driven through deep snow or thick mud.

1.5 Units, Symbols

Although different systems of units are used in different parts of the world, technologists are usually fully conversant with the various differences between British and American units (gallon, etc) and can easily convert units from one system to another. To avoid confusion the reader is advised *not* to change units in translated texts. The same applies to algebraic symbols, for instance *voltage* in English texts usually has the symbol V as opposed to U in German. The translator may wish to add a footnote, but the symbols themselves represent only a mathematical abstraction and should *not* be altered. A miscalculation involving units could mislead and irritate the reader of a translation; failure to realise that a changed symbol (*V*) occurs in the original text with a different significance (*Geschwindigkeit*) could make nonsense of *mathematical equations* and utterly confuse him.

In specific areas, such as Automobile Advertising, it may be helpful to change for instance *fuel consumption* in *litre/100km* into *mpg* (miles per gallon). But only if the translator himself has the necessary "feel" for figures. Otherwise it is not worthwhile. He may unwittingly find himself describing a *jet plane* with the fuel consumption of a *lawn mower*.

Figure 1: Mechanical Quantities

Quantity	v/s	SI-Unit	German
acceleration	v	$m.s^{-2}$	Beschleunigung
action	v	newton	Kraft
angle	s	radian	Winkel
angular velocity	v	$radian.s^{-1}$	Winkelgeschwindigkeit
area	s	m^2	Fläche
compression	v	newton	Druckkraft
compressive stress	v	$newton.m^{-2}$	Druckspannung
density	s	$kg.m^{-3}$	Dichte
distance	s	m	Abstand
energy	s	joule	Energie
force	v	newton	Kraft
friction	v	newton	Reibungskraft
gravity	v	newton	Gewichtskraft
impulse	s	$kg.m.s^{-1}$	Kraftstoß
inertia	-	-	Trägheit
mass	s	kg	Masse
moment	v	newton.m	Moment
moment of inertia	s	$newton.m^2$	Trägheitsmoment
momentum	v	$kg.m.s^{-1}$	Impuls
orbital velocity	v	$radian.s^{-1}$	Bahngeschwindigkeit
power	s	watt	Leistung
pressure	s	pascal	Druck
reaction	v	newton	Gegenkraft
rotational speed	v	rev/s,rpm	Drehgeschwindigkeit
speed	s	$m.s^{-1}$	Geschwindigkeit
strain	s	DL	Dehnung
stress	s	$newton.m^{-2}$	Spannung
tension	v	newton	Spannung
tensile stress	v	$newton.m^{-2}$	Zugspannung
thrust	v	newton	Schubkraft
torque	v	newton.m	Drehmoment

torsional stress	v	newton.m^{-2}	Torsionsspannung
traction	v	newton	Zugkraft
upward thrust	v	newton	Auftriebskraft
velocity	v	m.s^{-1}	Geschwindigkeit
volume	s	m^3	Volumen
weight	v	newton	Gewicht
work	s	joule	Arbeit

v/s = vector/scalar; m = metre; s = second; DL = dimensionless

Chapter Two

BASIC ELECTRICITY

The existence of electricity has been well documented since the experiments of Volta with electric cells at the beginning of the last century. Subsequent work by Faraday and other great pioneers demonstrated the relationships between electricity and magnetism around the middle of the last century; brilliant mathematicians such as Maxwell provided concise, elegant *vector equations* linking the various basic concepts; and far-sighted engineers like Edison and Marconi elaborated the many practical advantages which eventually brought the vast range of household appliances, from vacuum cleaners to personal computers, into every home.

Despite this, certain trivial, relatively obvious concepts such as the differences between *current* and *voltage* are poorly understood by many people. These basic electrical concepts now underlie numerous branches of technology and are the subject of this Chapter. A list of the *physical quantities* and *units* common to all branches of electrical technology appears in Fig.2A.

2.1 Voltage, Current

Current represents the rate of flow of *charged particles* through a conductor of finite cross section. Initially, it was believed that positively charged particles flowed out of an electrical source (a battery) at the *positive terminal*, continued flowing via the easiest path and eventually reached the point of lowest *potential* in the electrical arrangement, namely the *negative* *terminal*. The situation is rather like standing at the top of a smooth hill and emptying a box of tennis balls. All the balls should reach a wall built at constant altitude around the bottom of the hill at exactly the same instant, regardless of the path they have taken. All the balls had initially the same *potential energy* by virtue of being at the top of the same hill; on reaching the wall, their potential energy is converted into *kinetic energy* (the energy of motion). As they hit the wall, some of the kinetic energy is converted into heat and sound as the balls rebound back up the hill.

The electrical situation is similar. The *charge carriers* lose their *potential energy* gradually on the way "down" to *earth* through the *circuit*. Most of the energy is converted into *heat*, but if the circuit contains a light bulb or an electric buzzer some is also converted into *light* and *sound*. The *charged particles* then work their way back to the positive terminal by acquiring energy from the source, rather like an automatic lift taking the tennis balls from the wall back to the top. The *energy* required to keep the balls continuously rolling down the hill thus equals that required to operate the lift. In an electrical context, the energy required to give a certain quantity of *electrical charge*, namely 1 *coulomb*, a potential energy of 1 *joule* is defined as 1 *volt*.

The unit *ampere*, usually abbreviated in both the written and spoken language to *amp*, measures the rate of flow of charge at different points in the electrical circuit - similar to the number of tennis balls hitting a given wall each second. A *current* of 1 amp at a certain point in a *circuit network*, a so-called *node*, implies that a total charge of 1 coulomb passes the particular node per second. There are different schools of thought as to which, the *amp* or the *coulomb*, should be taken as the *basic physical quantity* in the SI unit system but this need not concern translators.

In reality, electric current flowing from the positive to the negative terminal through the circuit is not carried by positive charge carriers but by negative ones, so-called *electrons*; the physical quantity *coulomb* corresponds to a certain number (1.6×10^{19}) of electrons. In practice, current therefore really flows from the negative to the positive terminal, a situation rather like the tennis balls moving uphill all the time! The tennis ball analogy can be corrected simply by reversing the battery and assuming that the negative terminal represents the higher point on the hill, but in the field of electricity this slight error was realised rather late, in fact too late to be corrected. Since *electrons* are assumed to carry a *negative charge* (an arbitrary assumption initially) then so-called *conventional current* flows in the reverse direction to that of the true *electron current*.

Having said this it should be mentioned that in certain specific areas, such as *particle accelerators* or *thermionic tubes* (Chapters 4 and 6) electric charge may indeed be carried by *positive carriers*, so-called *positive ions*, corresponding to whole atoms which are free to move and which have lost one or more electrons. In the latter case the direction of flow of charge carriers is in fact the same as the *conventional current* direction.

A battery of *voltage* 9 volt creates a *potential difference* of 9 joule/coulomb (similar to a hill 9 metres high) across any component connected directly to the two terminals. The term *potential* is thus sometimes used in this field as a near synonym of *voltage*. Another near synonym used in connection with batteries and sometimes magnetic devices is *emf*, which originally stood for *electro-motive force* and implies the *voltage* generated by a particular *chemical* or *magnetic* arrangement. Regretably an old term for *voltage*, which dates back to the pioneer days of electricity, namely *tension*, still survives in the layman language of one or two isolated areas outside Electrical and Electronic Engineering. One example is the area of *automobile ignition systems* which frequently employs terms like *HT-circuit*, *LT-lead*, *LT-connection* (HT/LT = high/low tension); nevertheless, *voltage* is the preferred term and indeed the only possibility in terms like: *battery voltage*, *spark voltage*, *battery voltmeter*. Generally speaking, the translator may render *Spannung* as *voltage* in any electrical context; the terms *emf* and *potential* are pragmatic alternatives in specific cases, but *tension* should be avoided at all costs.

2.2 Resistor, Resistance, Resistivity

Water can flow much easier (with less turbulence) through a wide pipe than through a narrow one; it may also flow slightly easier through a copper pipe than a plastic one. There is a rough conceptual analogy between the degree of ease of flow and the so-called *conductance* of an electrical conductor. Electrical conductance is directly *proportional* to the length of the conductor and inversely proportional to its cross-sectional area. There is also a material constant involved, the so-called *conductivity*. In practice, however, it is more usual to consider not how easy it is for charge to flow but rather how difficult. The concept *resistance* is then employed (the *reciprocal* of *conductance*) and the material constant is termed *resistivity*. Resistance is measured in *ohm* and resistivity in a convenient compound unit, usually *ohm-cm*.

In Electrical Engineering and especially in Electronics, components are frequently used, which are designed to have a fixed *resistance* of a particular value. Such components are termed *resistors* and often have the *value* of the resistance stamped on the side, in the form of a standard international *colour code*. The code consists of four stripes, where the first two correspond to the first two *digits* and the third to the number of *zeroes* in the *value*. The fourth stripe represents the degree of *tolerance*, corresponding to a *percentage*, and provides a measure of how accurate the stated value of resistance is guaranteed to be.

The first *resistors* consisted of *coils* of wire of various dimensions and various metals or alloys but nowadays other materials are often used, particularly *semiconductor materials*. The resistor is often *coated* with or *encased* in a suitable insulating material. Most *variable resistors* or so-called *potentiometers* (since they divide the electrical potential) still consist of strips of metal with a moveable (adjustable) metallic contact which slides along the length of the strip. For example: the various *knobs* on TV or radio sets, stereo systems, electronic organs, for adjusting the *volume*, *tone*, *hold*, *brightness* are simply variable resistors.

2.3 Direct/Alternating Current (AC/DC)

When a light bulb is connected across the terminals of a battery, the current instantaneously reaches a certain level and thereafter remains constant until the bulb is disconnected. The electrical power dissipated in the form of *light* and *heat* can be calculated by simply multiplying the *current* passing through the bulb by the *voltage* applied across it. If the current is measured in *amp* and the voltage in *volt* the *power* calculated will be in *watt*. The resistance of the bulb in *ohm* can be calculated by *dividing* the values of voltage and current. This simple rule applies not just to light bulbs but most *components* of electric circuits when operated from a *dc source*, such as a battery. It applies to a limited extent too in more sophisticated components such as *transistors, diodes, IC's*.

A household lamp connected to the *mains* also dissipates electrical power in the form of light and heat, but the dissipation varies continuously over very short intervals (about 20 milliseconds) as the current rises smoothly from zero to a positive maximum, falls back through zero to a negative maximum and returns to zero to repeat the *cycle* again. The eye does not perceive these very rapid current changes but they are nevertheless there, as can be verified by anybody attempting to set the *pitch control* of a *record-player turntable* by shining a reading lamp onto a *stroboscopic raster* in a darkened room.

2.4 Capacitor, Inductor, Transformer

These first two devices *store* electrical energy under the appropriate conditions for short periods; the third changes the electrical *potential* of an *alternating signal* to a higher or lower value according to the way the device is connected.

A *capacitor* stores *electric charge*, the amount depending on the *voltage*. It is rather like a water tank with a special *safety valve* to progressively reduce the inflow of water as the tank fills up, for instance the *cistern tank* in a bathroom or the *loft tank* in British houses. The *capacity* of a water tank corresponds to the volume of water which the tank holds, and the *capacitance* of a *capacitor* indicates the amount of electric charge which the device can hold. *Capacitance* is measured in *farad*, a unit too large for many practical purposes and often substituted by *microfarad, nanofarad* or *picafarad*, particularly in Semiconductor Electronics.

Strictly speaking, the cistern tank analogy corresponds closer to the *capacity* of a *battery* than the *capacitance* of a *capacitor*. A *capacitor* is like a tank with several *inlet valves* at different heights, which shut off automatically at the respective levels. Just as the volume of water in the tank depends on the level of the particular inlet valve, so the amount of *charge* in a capacitor depends on the *voltage* applied. The parameter *capacitance* designates the charge stored per *unit voltage*, or in layman terms - the charge "per volt".

The first capacitors consisted of two metallic *plates* arranged parallel to one another and separated by a suitable insulating material, a so-called *dielectric*. The basic design is still much the same, but in order to maximise the *plate area* while minimising the dimensions modern capacitors are usually *wound* in a certain manner together with the *dielectric*. The dielectric material varies; paper is often used (paper capacitors) and occasionally certain *electrolytes* (electrolytic capacitors).

The terms *capacitor* and *capacitance* are firmly implanted in all fields of electrical technology. The older terms *condenser* and *capacity*, which date from the very early days are fast becoming obsolete but exist as "fossils" in small fields, for example hair dryers, model railways, etc.

An *inductor* consists basically of a *coil* of wire wound around a magnetic *iron core*. The device does not store *electric charge* but can store energy in the form of an *induced magnetic field*. This energy is subsequently converted into electrical energy (voltage) when the device is disconnected. The parameter *inductance* measured in *henry* specifies the characteristics of the component concerned. A *transformer* consists of two *inductors* wound on the same *iron core* and *coupled* by means of their joint magnetic field. The *coils* are termed *windings* in this case; the ratio of the *number of turns* in the so-called *primary* and *secondary windings* determine the ratio of the voltages in the *primary* and *secondary circuits*. Usually transformers can only be operated under *ac* conditions, since a direct current, if applied continuously, would burn out the respective winding. The *ignition system* of the conventional automobile contains a transformer for providing a *high-voltage spark*: the so-called *ignition coil*.

The layman terms *choke* and *coil* frequently occur in the technical literature as alternatives to *inductor* and *transformer*. These terms are not recommended for translators but their usage has become standard in certain compounds, for instance : *RF-choke* (Radio Circuitry), *AF-choke* (Amplifiers), *ignition coil* (Automobiles). The terms *AF/RF* imply *audio-/radio--frequency*.

A brief terminology of the main features of capacitors and inductors appears in Fig.2B.

2.5 Power, Wattage, Rating

Most electrical components dissipate heat, some also dissipate energy in other forms such as light, sound or even mechanical energy. The general term *power dissipation* covers the conversion of the energy of an electric current into any of the various forms. In the case of devices intended to dissipate power (light bulbs, speakers, electric heaters) the term *wattage* is often employed as a contextual synonym of *power rating*, which is the advisable power level for operating the particular device. Since it is not usual to *rate* other parameters (voltage, current, temperature) for simple devices the terms *rating*, *power rating* and *wattage* are sometimes contextually synonymous. However, in most cases, particularly in electronic circuits, *power dissipation* is an undesirable side effect and the power rating of these devices is specified by manufacturers to prevent the components from being destroyed by excessive internal heat; here the term *wattage* is not used.

The *instantaneous power dissipation* in an electrical device is calculated by simply multiplying the *voltage*, or more specifically the *potential difference* across the device by the *current* flowing through it at the given instant. When the *voltage source* is *dc* and a *resistive* device is used (resistor, heater, light bulb, etc) the power dissipation remains constant and the *instantaneous value* is the same as the *average* over a longer period.

Power in electrical devices operated from an *ac supply* is also calculated by multiplying *current* with *voltage*, but useful values are obtained only by taking a suitable average of current and voltage over one *cycle*, the so-called *RMS* (*root- mean-square*) values. For example, the household mains voltage of 220 volts is the *RMS value*. The *peak value* of the mains voltage (the maximum positive or negative value) lies somewhat higher than this (about 310 volt). A 22 watt aquarium lamp connected to a 220 volt mains supply thus conducts an RMS current of 0.1 amp.

This rule for calculating power in ac circuits is only applicable for simple components, such as light bulbs or resistors, where the ac voltages and currents concerned are *in phase*: the voltage and current rise from zero to reach their respective maxima at exactly the same instant. The power concerned is termed *dissipated power, power loss, resistive power* according to the context. If the current and voltage are slightly *out-of-phase* the dissipated power, the so-called *real power* is accompanied by a second parameter *reactive power*.

In electrical engineering most devices are *power-rated*. The circuit designer can determine the maximum permissible *current* for a given *voltage* or vice versa, by means of the simple calculation mentioned above. In the field of Electronics (Chapter 6) the components are also *power-rated* but since simple calculations are often not possible here, the devices are given *current* and *voltage ratings* as well.

2.6 Resistance, Reactance, Impedance

These terms are a frequent source of confusion for inexperienced translators and can only be completely understood by more advanced reading. The following brief account should help to eliminate the main sources of confusion.

The behaviour of *inductors* and *capacitors* in ac circuits is very different to that in dc circuits.

In a dc circuit containing a capacitor connected via a resistor and a switch *in series* to a battery, the behaviour of the current and the voltage of the capacitor is described as follows. At the instant of switching the capacitor voltage is zero, but rises gradually or rather *exponentially* to reach a maximum value equal to the battery voltage. The capacitor is then said to be *fully charged*. The current flow attains *its* maximum instantaneously, but falls exponentially to zero as the capacitor *charges up* (like the water flow in a WC cistern). The period of charging the capacitor is characterised by a parameter known as the *time constant* of the circuit, which depends on the respective values of *resistance* and *capacitance*.

The same circuit containing an inductor behaves somewhat differently. Owing to certain *electro-magnetic* effects the current through the device is initially zero but rises exponentially to a constant maximum when the magnetic fields have stabilised, after which the inductor acts like an ordinary piece of wire, a so-called *short-circuit*. The voltage, on the other hand, reaches its maximum instantaneously but then falls to zero. The time constant characterising the current level depends on the respective values of *inductance* and *resistance*.

The behaviour of both capacitors and inductors thus alternates between that of a *short-circuit* to that of an *open-circuit* with a certain *time lag* whenever the devices are switched on or off. This accounts for their very different behaviour in ac circuits.

In the case of capacitors or inductors connected to an ac source, both the *voltage* and *current waveforms* are of the same form (sinusoidal) but they are not *in phase* - they do not pass through *zero* or meet their respective *maxima* at the same instant. The *current phase* may *lead* or *lag* that of the *voltage* by as much as one quarter of a cycle, in which case the *dissipated power* is zero. Ideal capacitors and inductors do not increase their temperature when conducting an *ac current* and the concept *resistance* therefore has no relevance here. Instead another parameter, so-called *reactance*, is employed.

Reactance is measured in the same units as *resistance* (ohm) but unlike the latter, reactance depends not only on the component itself but also on the *frequency* of the *bias voltage*. *Reactive power* is measured in *watt*, but it should be remembered that this is not *power* in the true sense (no energy is lost or converted into another form) but simply a convenient parameter for circuit designers and other electrical engineers. *Reactive power* corresponds in fact to energy *stored* by a device during one part of the *voltage cycle* and released during another part. Attempts have been made by some authors to introduce the term *reactor* to cover both *capacitor* and *inductor* but this has *not* been accepted by any means.

When *capacitors* or *inductors* are combined with *resistors* the *current* and *voltage waveforms* vary by a certain fraction of a cycle usually expressed as an *angle* in *degrees* or *radians*, the so-called *phase angle* or *phase shift*. In pure resistors the phase shift is *zero*, in pure inductors it amounts to +90 degrees and in pure capacitors -90 degrees. In combinations of these components the phase shift may amount to any value between these extremes and the parameter obtained by dividing the *RMS voltage* by the *RMS current* is termed *impedance*. These phenomena are difficult to describe without using mathematics and further reading is strongly recommended here. The list of electrical quantities, derivations and units given in Fig.2A-B may help to clarify matters.

The terms *resistance*, *reactance* and *impedance* are clearly defined in English, and translation of English texts of this nature into German are straightforward. But in German there is a subtle difference in the semantic hierarchy: the term *Widerstand* is used for all three concepts and differentiated into *Verlust-*, *Blind-*, *Scheinwiderstand* only when necessary. In such cases the translator really needs to understand the text because substituting *resistance* in a context implying *impedance* or *reactance* could make nonsense of the translation.

Note: Some technologists dislike the term *power* and the unit *watt* in contexts involving *reactance* and *impedance*. They prefer the term *volt-amperage* and the units *var* and *VA*. *VA* stands for *volt-amp* and *var* for *reactive volt-amp*, both units being quantitatively identical to the unit *watt*. These new units have not caught on everywhere in Electrical and Electronic Engineering, possibly owing to the vast area covered by these fields, but the terms *volt-amperage* (Ge. *Scheinleistung*) and *reactive volt-amperage* (Ge. *Blindleistung*) are making headway.

2.7 Scalar/Phasor Quantities

Visualising an ac voltage or current as a two-dimensional *sinusoidal waveform* is a convenient way of understanding what happens in what mathematicians call the *time domain*. It is not, however, the only representation. The wave itself is of constant frequency and its magnitude at any point can be represented by a *vector*, rather like visualising what happens to one particular *spoke* of a bicycle wheel when the bicycle is turned upside down and the wheel rotated at constant speed. The *phase differences* - *phase lead* or *lag*, are indicated by the angle between the voltage and current vectors.

There is an obvious intuitive analogy here with that of *physics* (Chapter 1) where *forces*, *velocities*, and other *non-scalar quantities* are represented as vectors. Most people will remember *force polygons* from their school physics or using geometric diagrams to estimate for instance the *resultant velocity* of a plane flying at an angle to the wind. These are illustrations of the usage of *vector diagrams* to obtain a particular result without employing difficult numerical calculations. The situation in an electrical context is quite similar, but here *phasors* are involved instead of *vectors*, since the diagram depicts a *mathematical abstraction* in the *frequency domain* rather than in the *time* or *physical space domain*.

Impedances - combinations of resistors, capacitors and inductors, may also be specified as *phasor quantities* with a defined *magnitude* and *direction* (phase angle) as for *voltage* or *current* phasors. This is difficult to understand without relatively sophisticated mathematics and will therefore not be treated here. Fig.2A indicates which of the electrical quantities discussed so far are *phasor quantities* and which are simple *scalars*.

The translator need not hesitate to render the German *Zeiger* or *Vektor* as *phasor* in this context. To my knowledge, *phasor* has no other meaning in English except perhaps in the field of "Starship Enterprise". Nevertheless *Zeiger* has other meanings: *needle* (Meters); *hand* (Clocks); *pointer* (Astronomy); *indicator* (Instrumentation).

2.8 Transmission Cables

The first large-scale electrical power-transmission networks, such as those of Edison in North America, generated a *dc voltage*. *Dc*, however, has two great disadvantages not shared by *ac*: the *cables* from the *electricity generating plant* to the household user become much hotter and it is difficult to adjust the level of the voltage for household use. Despite Edison's loud objections and his famous experiments involving the electrocution of stray dogs in public with *jolts* of ac, the transition to *ac generators* was fairly rapid.

A *transmission cable* consists of two or more *wire leads* separated and surrounded by an insulating material. Under *dc conditions* the energy would simply flow in the form of *current* along the cables. However, the insulation between the wires makes the cable appear to have a series of *capacitors* connected in parallel, and the wire itself has an *inductive* effect. An *ac* transmission cable is thus like a string of pairs of capacitors and inductors which act as *oscillators* and effectively "bounce" part of the energy between the insulation and perimeter of the cable. This *reactive power* has to be retrieved at the far end of the cable, in order to accomplish *efficient* transmission.

These secondary effects are only important in long cables, that is cables whose length is greater than the *wavelength* of the ac voltage. At the standard *mains frequency* of 50 Hz this is not a problem for the cables of *household appliances*, but it does have to be considered by the *power transmission authorities* (in Britain the *Electricity Board*). To obtain the minimum *power loss* in the transmission lines the *load* of a particular consumer district has to be *matched* to the cables. *Power matching* can be achieved by a relatively unsophisticated technique consisting of adjusting the total cable length to a *whole number* of wavelengths.

Exactly the same problem occurs for the *roof aerials* of *television sets*. Here the cables are relatively short but because the *broadcast transmission frequencies* are quite high, the *wavelengths* concerned are low in comparison to the cable length and the effect is appreciable. Television maintenance engineers thus need to know something about power matching. To minimise these effects the *leads* of television cables are often *stranded* and *coaxial*, that is the outer lead consists of strands of very thin wire surrounding the insulation of the inner lead.

Figure 2A: Electrical Quantities

Quantity	p/s	SI-Unit	German
ac current	p	amp	Wechselstrom
ac voltage	p	volt	Wechselspannung
angular frequency	s	$rad.s^{-1}$	Kreisfrequenz
capacitance	s	farad	Kapazität
capacitative reactance	p	ohm	kapazitiver Widerstand
charge	s	coulomb	Ladung
conductance	s	mho	Leitfähigkeit
conductivity	s	$(ohm.m)^{-1}$	spezifische Leitfähigkeit
current	s	amp	Strom
dc current	s	amp	Gleichstrom
dc voltage	s	volt	Gleichspannung
emf	s	volt	Spannung
frequency	s	hertz	Frequenz
heat	s	watt	Wärmeleistung
impedance	p	ohm	Scheinwiderstand
inductance	s	henry	Induktivität
inductive reactance	p	ohm	induktiver Widerstand
phase shift	p	radian	Phasenverschiebung
potential	s	volt	Potential
power	s	watt	Leistung
reactance	s	ohm	Blindwiderstand
reactive volt-amperage	s	var	Blindleistung
resistance	p	ohm	Wirkwiderstand
resistance	s	ohm	Widerstand
resistivity	s	ohm.m	spezifischer Widerstand
time constant	s	second	Zeitkonstante
voltage	s	volt	Spannung
volt-amperage	s	va	Scheinleistung
wattage	s	watt	Wattleistung
wattage	s	watt	Wirkleistung

p/s = phasor/scalar	va = volt-amp	var = reactive volt-amp

Units

volt = joule.coulomb^{-1}	amp = coulomb.s^{-1}	watt = volt.amp
mho = ohm^{-1}	var = watt	va = watt

Figure 2B: Basic Electrical Terms

1	resistor	Widerstand
11g	wire-wound resistor	Drahtwiderstand
111g	rheostat	Schiebewiderstand
12m	resistance	ohmscher Widerstand
121a	loss resistance	Verlustwiderstand
122a	resistive impedance	Wirkwiderstand
2	capacitor	Kondensator
21g	parallel-plate capacitor	Plattenkondensator
22g	electrolytic capacitor	Elko
23g	ceramic capacitor	Keramikkondensator
24p	dielectric	Dielektrikum
25p	capacitor plate	Kondensatorplatte
26m	capacitance	Kapazität
3	inductor	Spule
31g	choke	Drosselspule
32p	coil	Wicklung
321p	turn	Windung
322m	coil resistance	Spulenwiderstand
33p	iron core	Eisenkern
34m	inductance	Induktivität

4	transformer	Transformator
41p	winding	Wicklung; Spule
411g	primary winding	Primärwicklung
412g	secondary winding	Sekundärwicklung
413m	turns ratio	Windungsverhältnis
414m	number of turns	Windungszahl
5	alternating voltage	Wechselspannung
51m	frequency	Frequenz
511m	angular frequency	Kreisfrequenz
52m	amplitude	Scheitelwert
53m	RMS value	Effektivwert
531a	RMS voltage	effektive Spannung
54a	alternating current	Wechselstrom
541m	RMS current	effektive Stromstärke
55m	phase	Phase
551m	phase angle	Phasenwinkel
552a	phasor	Zeiger
5521a	phasor diagram	Zeigerdiagramm

Chapter Three

MATERIALS SCIENCE

In industrial or university laboratories for work in fields such as Chemical Engineering, Semiconductor Technology or Nuclear Power, one of the first things visitors notice is a large chart hanging on the wall entitled *The Periodic Table of Elements*. The Periodic Table is an arrangement of the 106 chemical elements in order of their fundamental constituents, in a manner reflecting the properties of the elements concerned. Fig.3A contains an extract from this Table and Fig.3B, a list of *chemical symbols* of the elements commonly encountered by translators.

The early nineteenth century definition of an *element* was a substance which cannot be broken down by chemical or other processes into other elements. Nowadays, it is known that all elements can be broken down in theory by disrupting the *nucleus*, namely by bombardment with *radioactive* or other *elementary particles*, a process entailing one or more *nuclear reactions* (Chapter 4). *Elements* are thus defined in terms of the *elementary particles* which constitute them : *protons*, *neutrons* and *electrons*. The definitions entail three parameters - *atomic number*, *mass number* and *group number*, which are usually included in the Periodic Table.

A knowledge of the Periodic Table enables technologists to understand how atoms combine to form *molecules* and *chemical compounds*, as well as to predict a vast range of *material properties* - mechanical, optical, electrical, magnetic, thermal, chemical, radioactive, and others. Materials Science thus constitutes part of the basic education of all technologists, and contributes to the basic vocabulary of many different technical fields.

The distinction *substance/material/matter* is mentioned in passing (cf German *Stoff, Werkstoff, Materie*). *Substance* appears in chemical contexts, whereas *material* is reserved more for engineering and frequently implies something *man-made* as opposed to found in or obtainable from nature. Hence the terms *chemical substance, synthetic material, engineering material*; but there are exceptions, such as *raw material* (Ge. *Rohstoff*). *Matter* in the general language is roughly equivalent to *substance* - *organic matter, inorganic matter, vegetable matter*. In Chemistry and Biochemistry the term is applied to *living* or *organic substances* only, whereas in Physics *matter* is reserved for contexts involving Einstein's *General Relativity* and implies the alternative manifestation of *energy*. The conversion of *matter* into *energy* is the subject of Nuclear Physics and is widely applied in Astrophysics and Nuclear Technology.

3.1 Atomic Number, Mass Number, Group Number

Atoms consist of the elementary particles *proton, electron* and *neutron*. Protons and electrons bear opposite *electric charges* of equal magnitude; they have very different *masses*, the proton being much "heavier" than the electron. Protons and neutrons have approximately the same mass, but the neutron is a *neutral particle*: it bears no charge. The term *nucleon* covers both *proton* and *neutron*.

The *atomic number* of an element (Ge. *Ordnungszahl, Kernladungszahl*) is defined as the number of *protons* contained in the *nucleus* of one atom of the element. For example the atomic numbers of the following elements are: Fe - 26, Pb - 82, He - 2, meaning that the element *iron* has 26 protons, *lead* 82 and *helium* 2.

Mass number indicates the number of *nucleons* in the nucleus. It is an integer roughly equal to the *atomic mass* of the element. The atomic masses of the above elements are: Fe - 55.85, Pb - 207.19, He - 4.0026; *iron* has 56 nucleons, *lead* 207 and *helium* 4. Considering the *mass* numbers together with the *atomic numbers* (above) leads to the conclusion that *iron* has 30 neutrons, *lead* 125 and helium 2. The basic unit of atomic mass is the *a.m.u.* or *amu* (*atomic mass unit*). 1 *amu* corresponds approximately to the mass of

1 nucleon and is defined as one twelfth of the mass of the *carbon* atom. The *amu* is also defined in terms of the SI unit *kilogram* (a figure of the order 1.6 x 10^{-27}) .

Just as almost 99% of the matter of our solar system is concentrated in the sun, virtually the total mass of an atom is in the nucleus. The "light" electrons *orbit* the "heavy" nucleus like the planets orbiting our sun. But here the analogy ends. Whereas the planets remain almost in the same *plane* thus following one particular path (the *ecliptic*) in our night sky, the electrons are located in particular *orbital spheres*, so-called *electron shells*. This is rather like an egg with several shells, each spaced a certain distance apart. The first electron shell contains a maximum of 2 electrons, the second 8 and the third 18. The properties of a particular element are influenced by the number of electrons in the *outermost shell*, a parameter termed *valency*.

In the Periodic Table (Fig.3A) the elements are arranged in columns (so-called *groups*) according to the number of *valence electrons*. The *group number* of an element appears in Roman numerals at the top of the respective column in the Periodic System. Thus *carbon* (*C*) has group number IV and hence *valency* 4: four electrons appear in its outer shell. *Helium*, *neon*, *argon* and certain other elements appear in *Group Zero* of the Table. These elements have valency zero - their outer shells are "empty" (a chemist would say that their *valence shells* are *full*). The simple *shell model* of the atom involves other considerations not covered here, which account for the asymmetric appearance of the full Periodic Table.

3.2 Properties of Elements

Rows of the Periodic Table are referred to as *periods*. Elements situated adjacently in the Table tend to have very similar properties, for instance the elements Fe, Co, Ni (iron, cobalt, nickel) are all *magnetic*; those in the period containing uranium (U) are radioactive; those of *group number* II or less (eg. Mg, Fe, Ni, Cu, Zn, Ag, Au) are *metals* whereas those in the top right area of the Table are *non-metals*. The dividing lines in the Table between metals and non-metals also roughly designate the distinctions between *conductors* and *insulators*, both *thermal* and *electrical*.

Those elements occuring in Group IV, namely *carbon*, *silicon*, *germanium*, tend to form large regular *crystals* and are very useful in the electronics industry. Silicon and germanium were the first *intrinsic semiconductor materials* (Chapter 5). Elements of Groups III and IV, such as arsenic, phosphorus, indium, aluminium are injected into pure semiconductor materials in order to modify their *conductivity* (section 5.2). This process, known as *doping* (Ge. *dotieren*), is very important for the electronics industry.

The elements of Group 0, the so-called *inert elements*, also termed *noble elements* (Ge. *Edelelemente*) - *neon argon*, *krypton*, etc are the most *stable* elements of all. Due to their *zero valency* they do not take part in any chemical reactions and exist only as *molecules* of single atoms. In contrast, those elements whose *atomic number* exceeds 92, those after *uranium*, are highly unstable; they rapidly disintegrate to form other elements and may exist for sometimes only fractions of a second. Elements such as *uranium*, *radium*, *polonium* also disintegrate but the rate can be controlled and the released energy is used in nuclear power stations (Chapter 4).

3.3 Isotope, Nuclide

Many laboratories contain large charts which are extensions of sections of the Periodic Table of Elements, so-called *nuclide tables*. Indeed the concept *element* is of little significance in many fields now that *atomic structures* are better understood. Before defining *nuclide* an example is considered.

The basic *hydrogen* atom contains one proton and one electron but no neutrons. Nevertheless hydrogen atoms exist, even in nature, which do contain neutrons; these atoms are termed *isotopes*. The hydrogen isotopes have names : *deuterium* is the isotope of hydrogen containing one neutron (2 *nucleons*) and *tritium* that with two neutrons (3 nucleons). The "simple" hydrogen atom with zero neutrons (1 nucleon) is often referred to as *protium*. Since the properties of elements are determined largely by the *electrons* in the outermost electron shell - the so-called *valence electrons*, isotopes tend to have the same properties as the basic atoms and are often only distinguished by their higher *atomic mass*. More than 99% of sea water molecules, for instance, contain protium atoms, the rest deuterium or tritium.

The term *nuclide* covers any configuration of neutrons, protons and electrons existing as an atomic unit. *Isotopes* are thus different *nuclides* of the same element. Only the hydrogen isotopes have separate names: protium (H-1), deuterium (H-2), tritium (H-3), corresponding to atoms with 1, 2 or 3 nucleons respectively. Isotopes of other atoms are designated by their chemical symbol followed by the respective mass number: C-12, C-14, U-235, U-238 (pronounced "carbon twelve", "carbon fourteen", etc).

3.4 Atomic Bonding

When atoms combine to form molecules the type of *bond* involved may be broadly classified as one of three types: *electrovalent* (near synonym: *ionic*), *covalent* or *metallic*.

Electrovalent bonding occurs in *salts* such as *sodium chloride* NaCl. Atoms of valency 1 or 2 easily lose their outer electrons to other atoms of valency 6 or 7 and then remain together as *mutually attracted ions*. Sodium readily loses its single *valence electron* to chlorine. The attractive forces involved are often considerable. Consequently *electrovalent materials* generally have high melting and boiling points. The electrovalent bond NaCl is overcome, however, simply by dissolving the salt in water; indeed, in this case, the liberated ions are responsible for the apparently high *electrical conductance* of water. Water which has been chemically processed to remove all traces of natural salts is a poor conductor. Note: the term *salt* is a technical one referring not just to sodium chloride (so-called *common salt*) but any substance obtained by replacing the ionisable hydrogen of an *acid* by a *metal*. Thus, there are various *iron, magnesium, potassium* and *cobalt salts* as well as *sodium salts*.

Covalent bonding involves atoms or *clusters* of atoms with the same valency (usually 4). The valence electrons share the outer *shells* of the atoms involved alternately. *Covalent* bonding is responsible for the molecular structures of gases such as *oxygen* O_2, *hydrogen* H_2, *methane* CH_4 and also for the regular *crystalline structures* of materials such as *diamond* (crystallised carbon), *silicon* and *germanium*. The bonds involved are not normally as strong as electrovalent ones and in solid materials are often overcome by application of heat.

In materials involving *metallic bonding*, such as *copper*, a cloud of valence electrons is shared by all *ionised atoms* of the material, that is to say all *positive ion cores*. This *electron cloud* is responsible for the high *electrical* and *thermal conductances* of metals.

Strict definitions of the various bonding types requires complex mathematics, and is not dealt with here. Moreover, the same materials often employ different bonds under different conditions: most *plastics* result from covalent bonding whereas *ceramics* (such as glass) involve both electro- and covalent bonds. The terms *co-/electrovalency* frequently denote particular *bonding states*, and are related only indirectly to *valency*, a parameter characteristic of individual *elements* (section 3.1).

It is important to note that the German *Bindungskraft* is usually translated here by *bonding* rather than *binding force*. The term *bind* is used in connection with the forces inherent in the nucleus itself: those responsible for *binding* the various protons and neutrons into a unit. *Atoms* are *bonded* together to form *molecules*, *crystals*, etc, *nuclei* are *bound* by internal *nuclear forces* (Ge. *Kernbindungskräfte*). Confusion between *bind* and *bond*, or rather, between the lexeme groups *bind/binding/bound/bond* and *bond/bonding/-bonded/bond* occurs even among native-speaker translators working in this area, since the terms have slightly different meanings in other fields. The "usual" meaning of *bound* is *securely tied*, for instance the *tow-rope* of a broken-down car, whereas *bonded* often implies that two surfaces are *securely glued*, as in the context of adhesives.

3.5 Ion, Plasma

Any atom or molecule which has become separated from a *valence electron* becomes a *positive ion*. Various terms denote this same entity in different contexts: *cation*, *ion core*, *ionised atom*, *host atom*, and others. An atom which has *gained* an electron in its valence shell becomes a *negative ion* (or *anion*).

In *fluid conductors*, that is *gases* or *liquids* which conduct electricity, the terms *anion* and *cation* are preferable to *negative/positive ion* since the ions concerned are invariably attracted by either *anodes* or *cathodes*. The latter are *electrodes* (terminals) in the system arrangement with *positive* or *negative voltage bias* (section 2.1). Nuclear technologists often create an *ionised gas*, a so-called *plasma* and direct charged particles towards particular electrodes by means of electric or magnetic fields. Plasmas are widely used in *particle accelerators*; positive ions moving towards the negative electrode (the *cathode*) are termed *cations*. *Anion* is the collective term for electrons and any negative ions moving towards the positive electrode (the *anode*). The terms *anion/cation* occur in other fields involving *anodes* and *cathodes*, even though the appearance and function of the electrodes concerned may vary considerably; for instance in *television tubes*, *battery cells* or *electro-plating*.

In *solids*, the ions themselves generally remain at fixed *sites* in the material; only the electrons move. The terms *ion*, *positive ion*, *positive atom*, *ion core*, *parent atom*, *host atom*, *fixed atom* occur throughout the literature but denote, in solids, essentially the same concept - the German *Atomrumpf*. Selection of the "correct" English term in a particular context is often a matter of individual preference or common sense.

Like *Atomrumpf*, the German *Atomhülle* is often a problem for translators, since English-speaking technologists apparently have no need of the concept. *Atomhülle* (frequent synonym: *Elektronenhülle*) implies the set of electron shells which surround the nucleus of an atom in the manner in which the atmosphere, stratosphere and ionosphere surround the earth. Translation problems can sometimes be avoided by rendering *Schale* as *shell* and *Hülle* as shells.

3.6 Material Properties

Different technologists are interested in different *material properties*. A mechanical engineer may be interested in the *stresses* and *strains* to which a particular type of *perspex* (Ge. *Plexiglas*) may be subjected whereas the designer of a greenhouse is more interested in its *optical* parameters. Materials Science is a vast field and only the basic *chemical* vocabulary is presented in this chapter. Many *physical* properties and relevant parameters of *engineering materials* are covered in the remaining chapters, particularly those of Electrical, Electronic, Mechanical and Nuclear Engineering (Chapters 4,5,6,9).

Figure 3A: Extract from the Periodic Table of Elements

Group

I	II								III	IV	V	VI	VII	O
H														He
Li	Be								B	C	N	O	F	Ne
Na	Mg								Al	Si	P	S	Cl	Ar
K	Ca	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra													
		Ce	Pr	Nd	Pm	Sm	Eu	Gd						
		Th	Pa	U	Np	Pu	Am	Cm						

Figure 3B: Common Elements

English	Symbol	German
aluminium	Al	Aluminium
antimony	Sb	Antimon
arsenic	As	Arsen
boron	B	Bor
cadmium	Cd	Kadmium
calcium	Ca	Kalzium
carbon	C	Kohlenstoff
chlorine	Cl	Chlor
cobalt	Co	Kobalt

copper	Cu	Kupfer
fluorine	Fl	Fluor
gallium	Ga	Gallium
germanium	Ge	Germanium
helium	He	Helium
hydrogen	H	Wasserstoff
indium	In	Indium
iodine	I	Jod
iron	Fe	Eisen
lead	Pb	Blei
magnesium	Mg	Magnesium
manganese	Mn	Mangan
mercury	Hg	Quecksilber
neon	Ne	Neon
nickel	Ni	Nickel
nitrogen	N	Stickstoff
phosphorus	P	Phosphor
plutonium	Pu	Plutonium
potassium	K	Kalium
radium	Ra	Radium
silicon	Si	Silizium
silver	Ag	Silber
sodium	Na	Natrium
sulphur	S	Schwefel
tin	Sn	Zinn
tungsten	W	Wolfram
uranium	U	Uran
zinc	Zn	Zink

Figure 3C: Atomic Constituents/Interatomic Bonding

1	atom	Atom
11p	electron shells	Elektronenhülle
111p	electron shell	Elektronenschale
1111p	electron	Elektron
12p	nucleus	Atomkern
121p	nucleon	Nukleon
1211g	proton	Proton
1212g	neutron	Neutron
13m	valency	Valenz; Wertigkeit
14m	mass number	Massenzahl
141a	atomic mass	Atommasse
15m	atomic number	Kernladungszahl; Ordnungsz.
16a	group	Gruppe
17a	period	Periode
2	interatomic bond	Atombindung
21	electron-pair bond	Elektronenpaarbindung
22	ionic bond	Ionenbindung
23	covalent bond	kovalente Bindung
24	electrovalent bond	electrovalente Bindung
25	metallic bond	Metallbindung

Chapter Four

NUCLEONICS

Nucleonics is the general term covering the study of the atomic *nucleus*. It is closely connected with areas like *atomic physics*, *radiochemistry*, *nuclear power* and *radiocarbon dating* (archaeology). Like the field of electronics in the seventies this area is one where many translators feel out of their depth. Nevertheless in view of the chronic pollution of our planet due to the use of *fossil fuels*, there is likely to be an upswing in Nuclear Technology at the turn of the century; the importance of this field for translators is thus increasing constantly. This chapter gives a brief introduction to the phenomena of *radioactivity*, *nuclear fission* and to the many different *elementary* particles.

4.1 Radioactivity

The fact that certain materials are radioactive was realised almost a century ago when scientists, such as Becquerel, noticed that certain materials stored in closed boxes in dark rooms affected whatever *photosensitive material* happened to be nearby. *Visible light* was out of the question: the reason lay in some undiscovered form of *radiated energy*. Certain *uranium oxides* such as *pitchblende* emitted this energy, and a new element *radium* was discovered. Within two decades other eminent scientists, notably Rutherford, were experimenting with these "energy rays", which seemed to emerge "spontaneously" from certain materials in the absence of any other *energy source*. Those *rays* which passed through materials *opaque* to light were termed

X-rays. Other rays were distinguished according to their behaviour in magnetic fields: *alpha-*, *beta-* and *gamma-rays*.

The field has advanced tremendously since the days of Rutherford and many other types of radiation have been postulated and eventually confirmed, sometimes initially by *astrophysicists* studying *supernova*). Moreover, despite the fact that the terms *alpha-/beta-/gamma-ray* refer to very different entities and are not particularly appropriate the names have stuck. These rays and others are discussed in the following sections.

4.2 Particulate/Electromagnetic Radiation

Rutherford's experiments with *radioactive rays* in magnetic fields led to the conclusion that *alpha-* and *beta-rays* are composed of *particles* of fixed mass bearing opposite electric charges and moving at velocities approaching that of light. Subsequent experiments revealed that *alpha-particles* are *helium nuclei* (helium atoms "stripped" of their electrons); *beta-particles* are simply *electrons* moving at exceptionally high velocities with a resulting *relativistic increase* in *mass*, in other words the mass/energy relationship conforms to Einstein's Theories of General Relativity.

Gamma rays are not deflected by magnetic fields. Despite this, they are not *neutral particles* but a form of *electromagnetic radiation* similar to light rays or X-rays. A complete *spectrum* of all types of *electromagnetic energy* appears in Figure 4A; the appropriate range of *wavelengths* for each of the different waves or rays is also included.

When using a lawnmower, an electric drill or hair-dryer an electric current alternating at 50 Hz travels along the *mains lead*. This alternating current sets up an alternating magnetic field around the cable causing an *electromagnetic wave* to *propagate* through the atmosphere. These waves are of very low *amplitude* and of little practical usefulness since most of the *energy* is transferred not to the *wave* but to the *appliance* (lawnmower, etc).

Nevertheless Marconi discovered long ago that much more energy is *radiated* away from the *conductor* if the *frequency* of the current is increased to 100 kHz or more. The waves resulting are termed *radio-waves* and have *wavelengths* ranging from 1 metre to about 10 kilometres. *Microwaves*, whether used for cooking a turkey or communicating with a satellite, are also electromagnetic radiation of a higher frequency (and hence lower wavelength) than *radio waves*, and the same is true of *infra-red*, *ultra-violet* and *visible light waves* (Fig.4A). *X-rays* and *gamma rays* have wavelengths comparable to the dimensions of atoms. This means that under the appropriate conditions they could cause ionisation or even disrupt nuclei. Unlike light-rays, therefore, X-rays are not completely harmless to living organisms and gamma rays are extremely dangerous. Ionisation causes alterations to occur in living cells which lead to cancer and other ailments.

The unit of *distance* employed in Atomic and Nuclear Physics is named after the Swedish scientist Angström. One *angstrom* is equivalent to one ten millionth of a millimetre (0.1 nm). Since only gamma- and X-rays have wavelengths comparable to atomic dimensions (the diameter of an atom is of the order 1 angstrom), they are the only rays in the electromagnetic spectrum, capable of inducing *ionisation*. Other types of radiation, such as ultra-violet waves may also be harmful to living organisms (including people) but here the danger is due to the *excitation* of atoms and molecules, leading to excessive heat generation, rather than ionisation.

Alpha- and beta-rays are thus streams of atomic particles (ionised nuclei, electrons). X-rays and gamma rays are similar to light waves, and the energy is said to be carried by *photons*. The *photon* is not a particle but a "physical abstraction" visualised as a bundle of energy, a so-called *wave packet*. The adjective *particulate*, in expressions such as *particulate radiation*, *particulate energy*, *particulate phenomena*, implies that the energy is carried by *particles* of *non-zero mass* (alpha- or beta-particles) whereas its counterpart *electromagnetic* implies that *waves* are responsible (X-rays, gamma rays).

Note: The German *Strahl* (English: *stream*, *jet*, *beam*, *ray*) is sometimes a problem here for non-native English speakers. *Beam* is used when the *rays* are concentrated at a particular *focal point*, and *stream* when they move in the same general direction. *Jet* is not appropriate in the contexts discussed. There is an intuitive conceptual distinction between *ray* and *wave*, as in *light ray* and *light wave*, but no physical one. The German *Strom* is also sometimes problematic. For instance, *Plasmastrom* may imply *plasma current* (the electric current resulting from *ionised particles*), *plasma stream* (a "river" of *ionised* particles, often travelling in a circle), or *plasma flow* when attention is focussed upon the *flow rate, density* or *velocity* of the particles.

4.2.1 Radiation Energy

For small particles the SI unit of energy *joule* is too large, and is substituted by the *electron-volt, eV*. One *eV* is defined as the energy acquired or lost by a single electron in passing through a *potential difference* of 1 volt. This unit is used throughout Atomic Physics and Radiochemistry, not just for *electrons* and not just for energy due to *electric fields* (voltage) but for all elementary particles (protons, neutrons, alpha-particles, etc) and different energy forms. In Nuclear Engineering the unit *MeV, mega-electron-volt,* is more usual.

Radiation doses administered to people in hospitals or absorbed accidentally during *nuclear catastrophes* are measured in *J/kg* of body mass. Other convenient practical units, such as *rem* and *millirem*, are used as well (1 rem equals 1 cJ/kg). In Physics or Nuclear Power Technology, *radiation* is measured in the unit *becquerel* or *curie*. 1 *becquerel* corresponds to an *activity* of one nuclear disintegration per second; the *curie* is simply a larger unit of the same physical quantity, that is to say of *nuclear activity.*

Surprisingly, *rem* and the *becquerel* were rendered "obsolete" by standards institutions shortly before becoming "household words" after the Chernobyl disaster, but these units still occur in the technical literature and are unlikely to disappear now.

4.2.2 Wave/Particle Duality

In certain areas of Atomic or Nuclear Physics it simplifies mathematics if *particles* are treated as *waves* or *vice versa*. For instance, *free electrons* are normally regarded as particles, but in considering *electron orbits* in the respective *electron shells* (Chapter 3) they are treated as waves. Similarly, the Wave Theory of Light due to the early physicist Huygens rapidly superseded Newton's Particle Theory, but despite being considered a *wave* or rather *wave packet* the *photon* is often treated or even referred to as a *particle* of luminous energy (light). The concepts *wave* and *particle* are intuitively *extreme cases* but in practice physicists often regard them as *alternatives*. *Wave/particle duality* may well confuse translators but does not seem to bother scientists.

4.3 Radiosubstances

Certain *elements* or *nuclides* are *radioactive*. This means that under the appropriate conditions they *decay* spontaneously to form other nuclides and emit *alpha, beta, gamma* and other *radiation* in so doing. The prefix *radio-* in terms such as *radio-isotope, radio-element, radio-nuclide, radio-substance* is simply an abbreviation for *radioactive*.

Elements such as *radium, thorium* and *einsteinium* are natural radio-elements. Others such as *uranium-238* can easily be split. The various transition periods to different nuclides may take tiny fractions of a second or millions of years depending on the transition. In the case of nuclear power stations and atomic bombs the energy released during a *decay transition* may trigger off a *chain reaction* causing other atoms in the immediate vicinity to *disintegrate*. Such chain reactions are often started by bombarding nuclei of radio-substances with neutrons.

Fig.4B shows the natural decay sequence of U-238 (the uranium isotope with *mass number* 238) to the ultimate *stable* or *non-radioactive* form *lead*. Note that the total *decay time* is about 4 500 000 000 years, approximately the age of our planet! The various nuclides (notably *radium* and *polonium*) are indicated by their *chemical symbols*; the figures to the left of the symbols indicate *mass/atomic number* and correspond to the number of *nucleons/-protons* in the particular nuclide. There are many intermediate *transitions* in the decay sequence of U-238 which require *periods* of the order of seconds or minutes and which are omitted from Fig.4B.

4.4 Matter, Anti-Matter

An *ionised hydrogen atom* of the isotope *protium* is simply a *proton*. The ionised isotopes *deuterium* and *tritium* also have names: *deuteron*, *triton*. Like alpha-particles these are simply *bare nuclei*, namely atoms stripped of their electrons. Free protons, deuterons, tritons and alpha-particles are described as *bare nuclei*, *completely ionised nuclides*, *nucleon clusters*, *combinations of protons and neutrons*, *ionising radiation*, *radioactive particles* or *particulate radiation* according to the context. Other ionised nuclides also act as radioactive particles or, strictly speaking, *particulate radiation* but these particles are designated by nuclide symbols rather than names such as *deuteron*.

The above *nuclear particles* all bear a *positive* charge by virtue of the protons contained. Nevertheless in certain nuclear reactions particles are generated which have the same masses as the above but the opposite charge, *negative*. These particles are *anti-matter particles*: when an *anti-proton* comes into contact with a *proton* the result is complete *annihilation* of the two particles. *Anti-neutrons* exist too: particles with the opposite *spin* of *neutrons* (ie "rotating" in the opposite direction). These opposite particles also annihilate one another.

Anti-matter electrons, positively charged electrons, are termed *positrons*; the usual negative electron is then called a *negatron*. Thus *β-rays* are streams of *negatrons*. *β+ rays* also exist, namely *positron radiation*.

Other "particles" frequently involved in nuclear reactions are *neutrinos* and *anti-neutrinos*. These particles have *zero rest mass* and *zero charge* and are quite unlike *negatrons* or *nucleons* for instance. Nor are they like *gamma-rays* (photons) but a completely different entity. Neutrinos are a "by-product" of the reaction when a proton coalesces with a negatron forming a neutron. The opposite reaction, the splitting of a neutron into a proton and an electron generates anti-neutrinos.

Leptons, *mesons*, *baryons*, *muons*, *pions*, *kaons*, *bosons*, *hyperons*, *fermions* are among many other particles generated by nuclear reactions. These are only mentioned in passing since many scientists currently believe that there is an even more fundamental constituent of matter: the *quark*. Electrons, protons, neutrons and all the anti-matter particles are thought to be composed of *quarks*. Fig.4C contains a full hierarchic list of *elementary particles* with the various subcategories. A rough definition of each particle in terms of other particles can be obtained from the list. For instance: an *anti-neutron* is a type of *nucleon*, which is itself a subcategory of *baryon*, a type of hadron.

4.5 Fission, Fusion, Decay

The terms *stable/unstable* in the field of *radioactivity* are relative. Probably all nuclides undergo transitions eventually but in many cases the transition times are so long they are considered infinite. Materials, such as *lead* are therefore regarded as *stable*. Certain nuclides, such as carbon-14, decay naturally to form other nuclides (carbon-12) at a rate which corresponds to a regular *mathematical function*: the *exponential function*. The situation is analogous to the *discharge* of a capacitor (section 2.4) but the *time scale* is very much longer. The decay rate of nuclides is predictable; the *half-life*, the time taken for half the atoms in a particular sample to decay, may be of the order of thousands or even millions of years. Hence, substances like carbon-14 are extremely useful for archaeologists, palaeontologists, geologists, in estimating the *ages* of artefacts, bones or rocks.

Apart from the above areas, most radioactive transitions which are interesting for technologists are not left to nature but deliberately *induced*. In most cases, this entails the *bombardment* of nuclei of a particular radiosubstance (uranium, plutonium, etc) with concentrated beams of *elementary particles* (often *neutrons*) with the objective of *disrupting* some of the *nuclei* of the material concerned in order to make use of the energy released. Whether the energy is used to heat steam at a power plant or to create an atomic explosion, the principles are basically the same. By overcoming the *nuclear forces* responsible for binding the nucleons together in the nucleus, nuclides decay to form other nuclides with the release of large quantities of energy and of other elementary particles. The latter in turn disrupt further nuclei and may trigger off a *chain reaction*. Nuclear reactions involving the *disruption* of nuclides are termed *fission reactions* and the materials used, such as uranium or plutonium, are termed *fissile* materials.

Not only the *disruption* of nuclei releases energy. When nuclei or elementary particles are brought into extremely close proximity, within distances comparable to *nuclear dimensions* (fractions of 1 angstrom), the *electrostatic repulsion* of the *protons* is overcome and energy is *released* as the two nuclei *coalesce* to form a single large nucleus. Nuclear reactions of this type are termed *fusion reactions*. The energy reaching us from the sun is due to *nuclear fusion*: every second millions of *hydrogen atoms* coalesce to form helium.

4.6 Nuclear Power

At a conventional fossil-fuel electricity generating station the electricity is obtained as follows: the fossil fuel is ignited to provide *heat*; the heat converts water into *steam*; the steam drives *turbines*; the *rotational energy* of the steam turbines is converted via magnetic systems into *electrical energy* which is then *distributed* to the consumer via a system of cables, the *power distribution network*.

At a nuclear power station the procedure is the same except that the *heat* is provided by nuclear reactions, generally speaking *fission* reactions. For common radiosubstances, such as uranium-238, it takes many thousands of years for the *fissile material* to reach a stable non-radioactive form. Storage of used radioactive material, so-called *spent fuel* is therefore a major consideration of nuclear power plants and the costs involved may even exceed those of the initial *power generation*. So-called *reprocessing* of spent fuel often results in radioactive material which is even more hazardous.

Power generation by *nuclear fusion*, such as the mutual bombardment of *hydrogen* isotopes to form *helium*, is difficult to achieve in view of the tremendous temperatures or particle velocities involved. At the time of writing it is not a practical possibility.

Figure 4A: Broad Electromagnetic Spectrum

wave/ray	wavelength	German
telegraphic waves	10-1000 km	Telegraphenwellen
radio waves	1m-10 km	Radiowellen
microwaves	1mm-1 m	Mikrowellen
infra-red rays	1 micron - 1mm	Infrarotstrahlen
visible light	390-770 nm	sichtbares Licht
ultra-violet rays	10-100 nm	UV-Strahlen
X-rays	1pm-10nm	Röntgenstrahlen
gamma rays	0.1 - 1 pm	Gammastrahlen

1 micron = 0.001 mm   1 nm (nanometre) = 0.001 micron
1 angstrom = 100 pm   1 pm (picometre) = 0.001 nm

Figure 4B: Decay Transitions of U-238

mass number
atomic number   CHEMICAL SYMBOL
decay period (years/days)

238	226	222	210	206
92 U --->	88 Ra-->	86 Rn-->	84 Po -->	82 Pb
	4.5 billion yr	1620yr	26yr	129day

Figure 4C: Elementary Particles

1	elementary particle	Elementarteilchen
11	lepton	Lepton
111	light quantum (photon)	Lichtquant (Photon)
112	neutrino	Neutrino
113	anti-neutrino	Antineutrino
114	negatron	Negatron
115	positron	Positron
116	muon	Müon
12	hadron	Hadron
121	meson	Meson
1212	pion	Pion
1213	K-particle	K-Teilchen
1214	kaon	Kaon
122	baryon	Baryon
1221	nucleon	Nukleon
12211	proton	Proton
12212	anti-proton	Antiproton
12213	neutron	Neutron
12214	anti-neutron	Antineutron
1222	hyperon	Hyperon
12221	lambda-particle	Lambda-Teilchen
12222	sigma-particle	Sigma-Teilchen
12223	omega-particle	Omega-Teilchen

Figure 4D: Oscillation/Wave/Radiation

1	oscillation	Schwingung
11m	amplitude	Amplitude; Schwingungsweite
12m	frequency	Frequenz; Schwingungsanzahl
121a	angular frequency	Kreisfrequenz
13g	vibration	Vibrationsschwingung
14a	atomic vibration	Atomschwingung
141g	thermal vibration	Wärmeschwingung
14g	electromagnetic oscillation	elektromag. Schwingung
2	wave	Welle
21m	amplitude	Wellenbreite
22m	wavelength	Wellenlänge
23m	propagation velocity	Fortpflanzungsgeschw.
24a	wave packet	Wellenbündel
3	radiation	Strahlung
31	ionising radiation	radioaktive Strahlung
311	nuclear radiation	Kernstrahlung
3111	particulate radiation	korpuskulare Kernstrahlung
3112	ionising elecmgtc radiation	elektromag. Kernstrahlung
32	electromagnetic radiation	elektromag. Strahlung

Figure 4E: Nuclear Fission/Fusion

1	nuclear reaction	Kernreaktion
11m	binding energy	Bindungsenergie
12m	nuclear forces	Kernbindungskräfte
13g	nuclear fusion	Kernfusion
14g	nuclear fission	Kernspaltung
141a	nuclear disintegration	radioaktiver Zerfall
1411a	decay product	Zerfallsprodukt
14111g	radionuclide	Radionuklid
14112g	radiation	radioaktive Strahlen
1412m	number of atoms	Atomzahl
1413m	decay constant	Zerfallskonstante
1414a	decay period	Zerfallszeit
14141m	half-life	Halbwertszeit
15g	chain reaction	Kettenreaktion
16g	induced nuclear reaction	künstliche Kernreaktion
17a	radiochemical equation	Reaktionsgleichung

Chapter Five

SEMICONDUCTORS

The first *semiconductor materials* used were the elements *silicon* and *germanium*, both of which appear in Group IV of the Periodic Table of Elements and have four *valence electrons* (Fig.3A). Their atoms form large, regular *crystal lattices*, just as *carbon* another *tetravalent* element forms *diamond*. Although diamond crystals can be *grown* and indeed *industrial diamonds* are very important in certain branches of engineering (drilling, etc) they are not used in the semiconductor industry. Other materials, *compounds* such as *gallium arsenide* have similar *lattice structures* and electrical properties to those of silicon and germanium, and are also used in the manufacture of *semiconductor devices*.

Note: The term *semiconductor* is used by technical authors as a convenient short form of both *semiconductor material* and *semiconductor device*, but confusion is rare.

5.1 Semiconductor Devices

In the late sixties the devices most frequently employed in circuits were: *transistors*, *diodes*, *resistors* and *capacitors* (Chapter 6). The main reason extensive use was made of these components as opposed to *inductors*, *thermionic tubes*, and other devices which had a longer history of development was that the former were much smaller and very much cheaper. Initially semiconductor materials were used to make just transistors and diodes but it soon became possible to manufacture resistors and capacitors from semiconductor materials as well. It was then just a small step to the manufacture of complete *integrated circuits (IC's)* on single minute pieces of semiconductor material *(chips)*; continued refinements in technology have led to subsequent *miniaturisation* and *micro-miniaturisation*, resulting in *micro-chips*.

Recent years have witnessed a vast increase in the original variety of semiconductor devices, manufactured either as *discrete components*, namely individual devices such as the transistors - *FET*, *UJT*, *MOSFET*, or as components of *integrated circuits* (*switching IC's*, *operational amplifiers*, etc). Indeed the technology has even reached the point where complete *central processors (CPU's)* of certain computers are contained on single silicon chips. Basically, *IC technology* concerns the injection of *impurities* into pure semiconductor material, in order that particular *regions* in the material become *insulating* (to form *capacitors*) or *conducting* (to form *resistors*) or so that so-called *junctions* are produced (forming *diodes*, *transistors*, etc). The circuits themselves are designed initially by electronic engineers using discrete components and adapted by semiconductor technologists to obtain the desired pattern of *impurity concentrations*. The latter requires extensive use of computers and the final stage, the actual *IC manufacture*, is often fully automatic and carried out by *industrial robots*.

This Chapter is mainly concerned with the *internal* features and parameters of semiconductor devices and materials, those properties of interest to a semiconductor technologist. The *external* properties, namely those of interest to the circuit designer or IC manufacturer are discussed in Chapter 6.

5.2 Semiconductor Materials

Semiconductor materials have an electrical conductivity lying between that of *conductors* and that of *insulators*. This is a suitable introductory definition. However, the conductivity of semiconductors is far more dependent on electrical and thermal environments and on *impurity concentrations* than is the case for most other materials, and this is what really distinguishes them from conductors and insulators.

Indeed, *impurity atoms* of specific elements are deliberately injected into pure *monocrystals* of silicon or germanium in order to achieve particular conductivities, a process known as *doping*. Pure materials are termed *intrinsic semiconductors* and those which are doped *extrinsic*. A sample of extrinsic semiconductor material which has a surplus of *negative* charge carriers due to doping is referred to as *n-type material*; extrinsic semiconductors with a surplus of *positive* carriers are designated *p-type*.

Different parts of the same semiconductor are often doped alternately giving *n-type* and *p-type zones*. The simplest semiconductor device, the *diode* consists of two alternate zones *(pn)*, the *transistor* of three *(npn* or *pnp)* and the *thyristor* of four *(npnp)*. More complex devices have layers of different impurity concentrations indicated by the symbols: $n+$, $p+$, $n++$, etc. The pentavalent impurity elements *phosphorus* and *antimony* (Fig.3A) produce p-type zones. Trivalent elements such as *indium* and *aluminium* produce n-type regions. *Impurity atoms* causing p-type zones are termed *acceptors*; those producing *n-type* ones are called *donors*.

The distinctions *n-type/p-type*, *donor/acceptor*, *intrinsic/extrinsic* and their respective implications are discussed in more detail in the following sub-sections. A brief, systematic, bilingual terminology of semiconductor materials appears in Fig.5.

5.2.1 Donor Injection, N-Type Zone

The injection of atoms of a *pentavalent element*, (phosphorus, arsenic, antimony) into a monocrystal of *tetravalent* atoms (silicon, germanium) causes *imperfections* to occur at each *site* in the *crystal lattice* where an impurity atom resides. The impurities contain one valence electron more than the lattice atoms and since this extra electron cannot immediately be accommodated in the lattice structure it is available as a *charge carrier* for conducting electricity. Since each impurity atom *donates* one *conduction electron*, extrinsic conductivity is proportional to *donor concentration*.

In practice the charge is not carried throughout the material by the same *donor electrons*. Rather, each donor electron *dislodges* one of its immediate neighbour electrons in the lattice and occupies the resulting *hole*.

The liberated electron then acts as a charge carrier until it collides with another lattice atom, releases a third electron and occupies the new hole in the lattice structure. Thus the number of charge carriers remains constant but the charge itself is carried by many different electrons whose roles alternate between that of *bonding electrons*, which maintain the crystal structure intact, and *conduction electrons* which are *freely* mobile.

5.2.2 Acceptor Injection, P-Type Zone

The conductivity can also be increased by injecting atoms of trivalent elements, such as *aluminium*, *boron*, *indium*, into *intrinsic silicon*. Since these *acceptor atoms* have one valence electron less than silicon an *electron vacancy* occurs at each *lattice imperfection* (synonym: *distortion*). This vacant *hole* in the lattice encourages adjacent *bonding electrons* to move towards the imperfection and *fill* the hole. Although the impurity atom becomes ionised, it remains at the particular *lattice site* and does not become a *mobile charge carrier* itself. Nevertheless a *hole* occurs at the site vacated by the ionising electron, which in turn attracts further adjacent bonding electrons. Consequently, charge is carried by electrons but there is a movement of *holes* in the opposite direction. To simplify discussion and calculation the technologist regards the holes themselves as positive charge carriers, as if they were *mobile* ions.

5.2.3 Pn-Junction/Transition

A region of a semiconductor where there is an abrupt transition from p-type to n-type material is referred to as a *junction region* and the interface itself as a *pn-junction*. The junction region is just a few *microns* (thousandths of a millimetre) wide but consists of a smooth gradual *transition* from material with a high acceptor concentration to that with high donor concentration. It is a surprise to some people that the terms *transition* and *junction* are often contextually synonymous in this field: the *abrupt junction* in the physical sense constitutes at the same time a *smooth electrical transition*.

The *transition region* presents a *potential barrier* to charge carriers flowing towards it because, due to the nature of the device, it tends to become *depleted* of carriers itself. The ionised atoms in this zone of the crystal lattice create a region of *space charge* which acts as a barrier. The terms *transition region*, *barrier region*, *depletion region*, *space charge region* and *junction region* denote more or less the same concept and are frequent contextual synonyms.

5.3 Conduction

Whereas the conductivity of *metallic conductors* tends to decrease with increasing temperature, since it becomes more difficult for the charge carriers (electrons) to travel through the material without excessive collisions with *oscillating atoms*, the opposite occurs in semiconductors. At low temperatures almost all the *conduction electrons* are tightly *bound* to their *parent atoms* and to their *immediate neighbours* (adjacent atoms) in the crystal lattice. The few which are liberated obtain their energy from the *heat* applied or the *temperature* of the surroundings. The higher the *ambient temperature* the more electrons are released from their atomic bonds and the greater the conductivity becomes. This process continues until the crystal structure eventually breaks down, a process which is normally irreversible.

The conductivity of a piece of semiconductor material depends a lot on the degree of *purity* of the crystal, the *perfection*. Once a *pure crystal* is obtained the conductivity can be closely controlled by one or more of the following means : *application of heat*, *incidence of light*, *impurity injection*. Most semiconductor devices (diodes, transistors, thyristors, IC's, etc) depend entirely on *impurity injection* and are sold in *light-proof* metallic cases, also designed to dissipate any *internal heat* produced. Exceptions to this are the class of devices used as *sensors* in fire alarms, oven lamps, burglar alarms, etc. *Thermistors* (thermal resistors) are the main heat-sensitive semiconductor device, and *LDR's* (light-dependent resistors) the main photo-sensitive component. Pressure-sensitive (piezo-electric) devices also exist and there are semiconductors which detect radioactivity.

5.3.1 Intrinsic/Extrinsic Conduction

The conductivity of pure silicon monocrystals, so-called *intrinsic conductivity* arises mainly from the liberation of electrons by *thermal agitation* of the lattice atoms. It is thus very dependent on *temperature*. *Extrinsic conduction* differs from its counterpart *intrinsic conduction* in that the liberation of a fixed number of charge carriers is effectively guaranteed by the impurity concentration. *Extrinsic conductivity* is relatively independent of ambient temperature.

Extrinsic conduction is essentially determined by the donor/acceptor concentration but other factors are involved which depend on the material itself. A full discussion of these factors is beyond the scope of this book, but three expressions are sufficiently common in technical literature to warrant at least a brief note, namely: *quantum* mechanics, *energy gap* and mobility.

5.3.2 Quantum Mechanics

The terms *quantum*, *quanta*, *Quantum Mechanics*, *Quantum Theory* occur throughout the scientific literature of Semiconductor Materials and other areas, such as Nuclear Technology or Materials Science. Quantum Theory was developed in the twenties and thirties collectively by a number of theoretical scientists, notably Fermi, Dirac, Schrödinger, Heisenberg, and other pioneers of Atomic Physics. The theory uses complex statistical methods to predict aspects of *elementary particles* (energy, momentum, velocity, etc) which cannot be accounted for by the classical Newtonian Mechanics (Chapter 1).

Quantum Mechanics immediately provided many "correct answers" and is currently accepted as the theoretical basis of all materials sciences. Nevertheless, since there is no obvious link with either Newtonian Mechanics or General Relativity it was hotly contested at the time by other great scientists, including Einstein in his famous remark "God doesn't play dice!". The issue remains unsettled; it is the current dream of every physicist to find the "missing link" between the Mechanics of small bodies and that of large ones, between Quantum Mechanics and General Relativity (Newtonian Mechanics being a special case of the latter for bodies moving at low velocities).

5.3.3 Energy Gap, Mobility

The *energy gap* refers to the minimum *excitation energy* which an electron must acquire in order to leave its *host atom*. The term *gap* is used because subject to Quantum Mechanics the electrons can only receive *discrete quanta* of energy and cannot accommodate energy at all within a certain *forbidden range*. Once a lattice electron (bonding electron) acquires *this* energy it can acquire further energy and move freely through the crystal, thus becoming a conduction electron. The situation is rather like keeping frogs in a bucket. Some will acquire the necessary energy from food or the *ambient heat* to leap out of the bucket and are then free to move anywhere. Others will leap up and down persistently but not acquire sufficient energy to clear the rim of the bucket.

Energy gap is measured in *eV* and is a very important factor in determining other semiconductor device parameters, such as the *contact potential* of a pn junction, which in turn determines the *forward voltage* of a diode (approximately 0.7 volt for silicon diodes and 0.3 volt for germanium).

The *mobility* of *negative carriers* in a semiconductor crystal, whether intrinsic or extrinsic, is determined by the *statistical-average distance* which a liberated electron travels before colliding with a lattice atom and liberating a further electron: the so-called *mean free path*. The term is also applied to *holes* by analogy. Discussions of semiconductor materials may treat the *electron* and *hole mobility* separately. A distinction in extrinsic semiconductors occurs between *majority* and *minority carriers* too. In *p-type* material *holes* are the *majority carriers*, electrons the *minority carriers*. In *n-type* semiconductors electrons are the majority carriers.

There are often orders of magnitude in the differences between *majority* and *minority carrier mobility*. Generally, in intrinsic or lightly doped material *electron mobility* exceeds *hole mobility*, that is electrons tend to travel further before *vanishing* than holes.

Figure 5: Semiconductor Materials

1	conduction	Leitung
11g	intrinsic conduction	Eigenleitung
12g	extrinsic conduction	Störstellenleitung
13m	conductivity	Leitfähigkeit
131g	directional conductivity	richtungsabhängige Leitfähigkeit
14a	conduction process	Leitungsvorgang
141a	charge carrier	Ladungsträger
1411g	conduction electron	Leitungselektron
14111a	mobile electron	frei bewegliches Elektron
1412g	hole	Loch
14121a	electron vacancy	Defektelektron
1413m	mobility	Beweglichkeit
2	energy band	Energieband
21g	valence band	Valenzband
22g	conduction band	Leitungsband
23a	energy gap	Energielücke
231a	forbidden zone	verbotene Zone
3g	crystal	Kristall
31g	monocrystal	Einkristall
32a	crystal structure	Kristallaufbau
321a	spatial arrangement	räumliche Anordnung
322a	crystal lattice	Kristallgitter
3221p	lattice atom	Gitteratom
32211g	impurity atom	Fremdatom
3222a	lattice bond	Gitterbindung
32221g	completed bond	gesättigte Bindung
32222p	ion core	Atomrumpf
32223p	bonding electron	Bindingselektron
32224a	electron vacancy	Elektronenlücke
3223a	imperfection	Störstelle

4	doping	Dotieren
41a	impurity element	fremdes Element
411g	donor impurity	Donator
412g	acceptor impurity	Akzeptor
42a	extrinsic material	dotierter Halbleiter
421g	n-type material	n-Halbleiter
422g	p-type material	p-Halbleiter
5	pn-junction	pn-Übergang
51a	reverse-biased	in Sperrichtung gepolt
52a	forward-biased	in Durchlaßrichtung gepolt
53a	potential barrier	Potentialschwelle
54a	region; zone	Schicht
541g	n-type region	n-Schicht
542g	p-type region	p-Schicht
543g	transistion region	Übergangsbereich
5431a	barrier region	Sperrschicht
5432a	depletion region	Grenzschicht
5433a	space charge	Raumladung

Chapter Six

ELECTRONICS

Chapter 2 discusses the *electrical devices*: *resistor*, *capacitor*, *inductor*, *transformer*. Such devices are used for regulating voltages and currents in *power networks*, *generators*, *electric motors* and *electrical machinery* employed in factories, households and vehicles. Similar devices are used in electronic circuits for *amplifiers*, *tuners*, *radio transmitters*, *musical instruments*, but these devices are much smaller and are *rated* for lower currents and voltages. Electronic circuits tend to be far more complex than electrical ones and employ a wider range of devices (tubes, transistors, IC's, switching devices), many of which are manufactured from semiconductor materials. The terms *circuit component*, *component*, *device* are closely related in this field and contextually synonymous in the expressions: *semiconductor component*, *semiconductor device*.

Fig.6A contains a hierarchic list of the main circuit components used in the field of electronics. The hierarchy is a *generic* one, that is terms "lower" in the hierarchy (having a *longer* classification code) are *types* of the respective *superordinate* concept. Readers unfamiliar with these devices can use the hierarchy to extract broad definitions of each device in terms of neighbouring concepts. For instance: "an *avalanche diode* is a type of *semiconductor diode*, other types are *zener diode*, *tunnel diode*, *varactor diode*". Similarly: "the term *semiconductor component* is contrasted with *tube component* and covers the *subordinate* concepts *semiconductor diode*, *transistor*, *thyristor*". The root concepts of Fig.6A - *active devices*, *passive devices*, *discrete components*, *modules*, *transducers*, are discussed in the following sections. This chapter also deals with *switching devices*, which have many applications: alarm circuits, flashing light displays, electronic automobile ignition systems, and above all digital computers.

6.1 Active/Passive Devices

Circuit components are termed *active* or *passive* according to whether the relationship between the current conducted by a particular device and the voltage applied across it is *linear* or not. The three main passive devices are: *resistor, capacitor, inductor. Tubes, diodes, transistors, thyristors* are examples of active components.

In passive components used under ac conditions the instantaneous ratio of *voltage* to *current*, the so-called *impedance*, is constant, that is it does not change according to the voltage or current applied. It may vary according to the *frequency* of the *ac signal*, but impedances of passive devices can be determined at a given frequency numerically

The *impedance* of a *resistor* is numerically equal to its *resistance*. For inductors and capacitors the parameter *resistance* is not relevant except to specify minimal side effects, such as *coil resistance* (inductor), *dielectric resistance* (capacitor), which result in energy losses due to heat. In "perfect" inductors and capacitors operated from an *ac source*, the ratio of the *RMS voltage* to the *RMS current* at constant *frequency* is constant and corresponds to the parameter *reactance* (Chapter 2). *Reactance* can be calculated from the following simple formulas : *inductive reactance* = *wL*; *capacitive reactance* = *1/wC*. The symbols *L* and *C* correspond to the values of *inductance* and *capacitance*; *w* (omega) represents the *angular frequency* of the signal and is measured in *radian* (section 2.7).

Parameters for active devices, particularly tubes and transistors, cannot be specified as easily as for the passive components. To simplify specification the devices are often considered as consisting of two or more *equivalent circuits*, for instance a *control circuit* and a *controlled circuit*. The details need not concern us here, but equivalent circuits often contain so-called *equivalent sources*, which have nothing to do with the *dc power source* (Stromversorgung) of the circuit itself. *Equivalent sources* are merely a convenient *mathematical abstraction*; there are two types: *voltage* and *current sources*. To the electronics specialist, *power source* and *current source* are separate concepts, one concrete the other abstract. The use of *Stromquelle* by German technologists for both concepts frequently confuses translators. Generally, *Stromversorgung* can safely be rendered as *power source* (syn. *power supply*).

The concept *passive component* strictly includes *transformers* as well. The latter have features in common with *inductors* but in view of their different function the simple parameter *impedance* is not sufficient. Active devices fulfil two main functions: *switching* and *amplifying*, which form the basis of two enormous branches of the electronics industry, namely *computing* and *entertainment* (radios, hi-fi equipment, video recorders, etc).

6.2 Modules, Discrete Components

Until the late sixties most electronic circuits consisted solely of interconnected *transistors*, *diodes*, *resistors* and *capacitors*. *Laboratory circuits* were developed using so-called *breadboards*, that is *insulated circuit boards* containing vast arrays of tiny holes used for attaching and *soldering* the various components. *Industrial circuits* were assembled in much the same way but used *PCB's* (printed circuit boards); the *connections* between the individual components resulted by *etching* a *copper path* onto the *circuit board* itself rather than simply using *connecting wire*. The seventies brought a further refinement in that circuits frequently required, such as *amplifier* or *switching circuits*, were produced in billions on tiny *silicon wafers* hardly bigger than single transistors. These *integrated circuit modules* or simply *IC's* led to even more sophisticated circuit designs.

Discrete electronic devices (transistors, diodes,etc) still have many uses, since only specific applications warrant the investment in *IC-modules*. The disadvantage of IC's is their sensitivity to internal heating. Hence the *power stages* of amplifiers, for instance, invariably employ *discrete components*. The term *module* is often a contextual synonym of *IC* but occasionally it implies an interchangeable circuit constructed from discrete devices, such as the *printed circuit modules* of certain televisions.

6.3 Transducers

There is a small but nevertheless very important category of semiconductor devices whose *resistance* varies linearly according to one feature of the *external environment*. These special *semiconductor resistors* may be *heat-sensitive* (thermistor), *light-sensitive* (LDR) or *pressure-sensitive* (piezo-electric resistor). The devices have important industrial as well as domestic applications: burglar alarms, fire alarms, oven warning lamps, *pick-ups* for acoustic musical instruments; they convert different forms of energy into electrical energy and are referred to collectively as *transducers*. There are transducers for sensing optical, acoustic, thermal, magnetic and mechanical energy (light, sound, heat, magnetism and pressure) and semiconductor transducers exist which respond to radioactivity.

Some devices operate in the reverse direction, in that they convert *electrical signals* into an *optical* ones. The most famous is the *LED* (light-emitting diode) found in the *digital displays* of calculators, digital watches, digital meters.

6.4 Switching Devices

There is a further category of component which cuts across the generic classification of Fig.6A: *switching devices*. Apart from *manual switches*, such as on/off switch, light switch, speaker switch, etc, electric circuits often incorporate *electronic switches* which act as *circuit breaker* in the event of an *overload*. *Relays* were once used for this purpose but their place has been taken over to a large extent by *thyristors*. There are many different types of thyristor, some with lengthy, complex names, for instance: *cathode-controlled reverse-blocking thyristor triode* (CCRBTT). Thyristors are further differentiated according to whether a *short-circuit* or an *open-circuit* is required and whether or not *contact* is to be restored electronically after a short period. Other electronic devices can also be applied for switching purposes, for instance transistors.

The first electronic switching device was the *relay*, which was used alongside *thermionic triodes* in the *switching circuitry* (*multivibrators*, *registers*, *logic gates*) of early computers. It was superseded by the *transistor*. *Switching* IC's are simply a further refinement of transistor technology but one which has involved considerable industrial effort spread over several *computer generations*. It is now possible to manufacture complete *computational modules*, *ROM*, *RAM*, *CPU*, etc, on single *silicon* chips.

6.5 Terminal, Lead, Electrode

For *batteries*, these terms represent different concepts. *Electrodes* are the *conducting rods*, *anode* and *cathode*, in each *battery cell*. They are immersed in the *electrolyte*, the battery acid. *Terminals* are the *external contacts*, connected internally to the battery electrodes; most batteries have two terminals: positive and a negative. *Leads* are any external *insulated* or *bare wires*, soldered or otherwise connected to the *battery terminals* in order to provide contact with the *load* (circuit, lamp, etc). It is usual to apply vaseline to the *terminals* of a car battery to ensure good contact with the battery *leads*; access to the *electrodes* is not possible unless the acid is removed.

For *semiconductor components* the terms are used analogously, though rather more loosely, since the only access a circuit technologist has to the semiconductor itself is via the external *leads*. The *electrodes* of *active devices* are named, since the device may be destroyed if connected wrongly. The corresponding lead or terminal attached to the electrode is usually given the same designation as the electrode itself: *collector*, *anode*, *drain*, etc. Fig.6B summarises the terms denoting electrodes, leads or terminals of the main electronic devices.

The *tube devices*: *diode*, *triode*, *tetrode*, *pentode*, commonly found in TV sets, have 2, 3, 4, 5 *electrodes* respectively. These consist of: one *anode*, one *cathode* and up to three *grids* (Ge: *Gitter*). *Bipolar transistors*, that is *npn-* or *pnp-transistors*, no matter how specialised, all have three electrodes termed: *collector*, *emitter*, *base*; so do *field-effect transistors*, but their electrodes are termed: *source*, *drain*, *gate*. Other devices may use mixtures of these terms: the thyristor electrodes are *anode*, *cathode*, *gate*. In devices designed to dissipate substantial heat (above 0.1 W), one of the *terminals* is usually the *case* itself; for instance: in *power transistors* the transistor case provides the connection to the collector electrode.

6.6 Heat Dissipation

All semiconductor devices are particularly susceptible to heat. Even a temperature of 50 C may destroy them. It is thus usual to specify the *maximum heat dissipation* tolerated by the device both with and without a suitable *heat sink*. Since the *thermal dissipation* is easily measured by calculating the product of voltage and current, the terms *power* and *heat* are sometimes contextually synonymous, as in: *power-/heat-/thermal dissipation*. For active devices the *dissipated power* depends on the *bias*, the voltage used to operate the device; it is usual to superimpose a graph of the maximum power dissipation, the so-called *power hyperbola* onto the *characteristic curve charts*. These are charts specifying the *current* conducted by a device at given *voltages*, which are supplied by the manufacturer together with the devices. Often the short term *characteristics* (Ge: *Kennlinienfelder*) suffices.

Capacitors used in electronic circuits generate virtually zero heat, and resistors are encased in a suitable material to rapidly dissipate any internal heat. Thermal dissipation in inductors and transformers is minimal and appropriate facilities are included in the design of the components: *core dimensions*, *windings*, etc.

Diodes, transistors and thyristors handling power as low as 10 mW need a suitable *metallic case* to get rid of the heat rapidly. Often the device is mounted such that the case itself is the terminal for one electrode. This technique provides good *thermal* contact between the device and casing but may still not be sufficient for powers of say 100 mW, when a *heat sink* becomes necessary, namely a suitable arrangement of *metallic fins* which dissipate the excessive heat by *convection*. For small transistors *star heat sinks* are available which are attached to the casing and can be removed at will. Larger transistors and other devices have to be *bolted* onto a suitably large *fin heat* sink.

6.7 Device Parameters

Resistors, capacitors, inductors are characterised by the parameters: *resistance, capacitance, inductance*. The parameter name is sometimes used as a synonym for the component itself - in expressions like "a resistance of 3 mega-ohm", "a capacitance of 30 microfarad", but this practice is not recommended for translators. The parameter values of discrete passive components are given on the component itself, often in the form of a convenient *colour code*, particularly in the case of resistors.

Active components cannot be specified by single parameters. Instead *characteristic curve charts* are available from the manufacturer which illustrate the electrical behaviour, and are known as *characteristics*. *Parameters* specified by manufacturers are taken from a standard set of *device characteristics* and correspond to *gradients, intercepts, limiting* and *mean* values. Generally speaking, the specified parameter is only applicable in a particular electrical (or thermal) *environment*. For example, the *current gain* of a bipolar transistor (the ratio of collector current to base current) is specified only for small increments of *base current* at a particular *collector-emitter voltage*. A full discussion of these parameters would constitute a book in itself. The most frequent *IC parameters* are mentioned below, namely *input impedance, output impedance, amplification factor, response time, transition time*. Parameters of *junction devices* (diodes, transistors, thyristors) are discussed in section 7.4.

Input/output impedance are common to all modules. An *ideal module* should have infinite input impedance (in order not to load the *signal source*) and zero output impedance (so that the maximum signal reaches the output load. *IC amplifiers* require a further parameter *amplification factor* which usually designates the ratio of the *output signal* to the *input signal*. Sometimes the terms *gain* or *voltage gain* are employed instead, especially if the IC is not a *voltage amplifier* but a *current amplifier* (current gain). *Response time* and *transition time* refer to *switching IC's*; they concern the period of response to an input control signal and the period of transition of the output voltage level when switching from one state to the other; both periods are of the order of *microseconds* or *nanoseconds*.

Figure 6A: Electronic Circuit Devices/Modules

1	passive component	passives Bauelement
11	resistor	Widerstand
12	capacitor	Kondensator
121	adjustable capacitor	Trimmer
13	inductor; choke	Spule
131	AF-choke	NF-Spule
132	RF-choke	HF-Spule
14	transformer	Transformator
2	active component	aktives Bauelement
21	tube; valve	Röhre
211	thermionic diode	Diodenröhre
212	(thermionic) triode	Triode
213	pentode	Pentode
22	semiconductor device	Halbleiterbauelement
221	semiconductor diode	Halbleiterdiode
2211	Zener diode	Z-Diode
2212	tunnel diode	Tunneldiode
2213	varactor diode	Varaktordiode
222	transistor	Transistor
2221	bipolar transistor	pnp/npn-Transistor
22211	switching transistor	Schalttransistor
22212	power transistor	Leistungstransistor
2222	UJT; unijunction transr.	UJT; Doppelbasistransistor
2223	FET; field-effect transr.	FET; Feldeffekttransistor
22231	MOSFET	MOSFET
223	thyristor	Thyristor
3	light-emitting device	Leuchtelement
31	LED (light-emitting diode)	Leuchtdiode
32	LET (light-emitting transr)	Leuchttransistor

4	control device	Steuerelement
41	light sensor	Fotoelement
411	LDR	Fotowiderstand
412	photo-electric diode	Fotodiode
413	photo-electric transistor	Fototransistor
414	photo-electric thyristor	Fotothyristor
43	heat sensor	wärmegesteuertes Element
421	thermistor	Wärmewiderstand
4211	NTC-resistor	NTC-Widerstand
43	pressure sensor	druckgesteuertes Element
431	pi-tran	Pitran
44	magnetic sensor	magnetfeldabhängiges El.
441	magnistor	Magnistor
5	IC module	IC-Modul
51	operational amplifier	IC-Verstärker
511	voltage amplifier	Spannungsverstärker
512	current amplifier	Stromverstärker
52	comparator	Komparator
53	multivibrator	Multivibrator
54	oscillator	Oszillator

Abbreviations

AF/RF	audio/radio-frequency
NF/HF	Nieder-/Hochfrequenz)
MOSFET	metal-oxide semiconductor field-effect transistor
LDR	light-dependent resistor
NTC	negative temperature coefficient
pitran	piezo-electric transistor

Figure 6B: Terminal/Lead/Electrode Designators

1	battery: positive/negative terminal	Plus-/Minuspol
2	transformer: primary/secondary terminal	Primär-/Sekundäranschluß
3	thermionic device terminals	
	diode: anode/cathode	Anode/Katode
	triode: anode/cathode/grid	Anode/Katode/Gitter
	tetrode: anode/cathode;	Anode/Katode
	control/screen grid	Steuer-/Schirmgitter
	pentode: anode/cathode/retard grid	Bremsgitter
4	semiconductor connections	
	diode: pos/neg connection	Plus-/Minus-Anschluß
	transistor: base/emitter/collector	Basis/Emitter/Kollektor
	FET: source/gate/drain	Source/Gate/Drain
	thyristor: anode/cathode/gate	Anode/Katode/Gate

Figure 6C: Semiconductor Device Parameters/Terminology

1	diode	Diode
11a	bias mode	Betriebsrichtung
111g	conducting mode	Durchlaßrichtung
1111a	forward-bias voltage	Durchlaßspannung
1112m	contact potential	Schleusenspannung
112g	non-conducting mode	Sperrichtung
1121a	reverse-bias voltage	Sperrspannung
1122m	breakdown voltage	Durchbruchspannung
1123m	residual current	Reststrom

2	transistor	Transistor
21m	saturation voltage	Sättigungsspannung
22m	current gain	Stromverstärkungsfaktor
23a	characteristic curve chart	Kennlinienfeld
231g	input characteristic	Eingangskennlinie
232g	output characteristic	Ausgangskennlinie
233g	transfer characteristic	Transferkennlinie
234a	load-line	Lastgerade
235a	power hyperbola	Leistungshyperbel
3	thyristor	Thyristor
31g	conducting mode	
	ON-state	Durchlaßzustand
32g	non-conducting mode	
	OFF-state	Sperrzustand
33m	trigger voltage	Nullkippspannung
34m	holding current	Haltestrom
4	IC module	IC; IS
41g	IC amplifier	IC-Verstärker
411m	input impedance	Eingangswiderstand
412m	output impedance	Ausgangswiderstand
413m	amplification factor	Verstärkungsfaktor
42g	switching IC	IC-Schalter
421g	response time	Ansprechzeit
422g	transition time	Schaltzeit

Chapter Seven

ELECTRICAL ENGINEERING

Basic Electrical Engineering is a mature field whose vocabulary has remained relatively consistent since the thirties. *Electrical engineers* deal with areas like *household wiring, electrical machinery, automobile electrics*. However, they generally have little idea of how to repair a television set or stereo system, nor much conception of *satellite communications, computer hardware, aircraft control* or *industrial robots*. The latter is the domain of the *electronic engineer*, a field which has grown at a phenomenal rate since the sixties and whose vocabulary has changed accordingly.

Electrical Engineering can be broadly divided into four areas: *heavy/-light electrical engineering, electronics and microelectronics*. Heavy engineering deals with power generation and distribution, work involving currents of a thousand amp or more, whereas *light electrics* covers household, automobile and other daily applications - dish washers, cookers, lighting, etc, handling currents usually below 20 amp. Electronics operates in the micro-/milliamp range, and concerns *amplification, broadcast reception, control systems*, and other equipment employing both *discrete components* (diodes, transistors, capacitors) and *IC's*. Microelectronics (nano-/pica-amp) deals with IC's themselves, namely complex circuitry, designed and tested at the milli/-microamp level but *scaled down*, in order to improve efficiency and reduce production costs. To refer to a designer of microelectronic circuitry as an electrical engineer is like calling a watchmaker a *mechanic*. The adjectives *electric(-al)/electronic* are thus used relatively rigidly throughout the field, even where differences in the objects concerned appear to a non-specialist as minor ones: with nouns like *circuit, device, component*.

All areas mentioned above derive from the branch of Physics known as *Electricity* (Chapter 2); the terms *electrical engineer/(-ing)* are employed in this chapter in both the broad and the narrow sense.

7.1 Engineer, Technologist, Technician

Attempts by various institutions to introduce the term *Electrical Technology* to cover all areas involving electrical systems (Ge. *Elektrotechnik*) have not managed to oust the current, lexically and etymologically misleading, global term *Electrical Engineering*. The title *engineer* does not imply that the person concerned knows anything about *engines*, simply that he or she holds a university degree in an appropriate subject, such as *Electrical Engineering*, *Computer Engineering* or *Chemical Engineering*. *Technologist* is the general term for *engineer*, whereas *technician* is a profession involving simple *maintenance* of mechanical, electrical, chemical or other equipment, for instance a *laboratory technician*. An *electrician* is a person responsible for laying *cables*, installing *electrical sockets*, *switches* and *lamps* in buildings, factories, vehicles, etc; like *technician* it is a profession requiring practical rather that intellectual skills, for instance *auto-electrician* (automobile electrician). A similar distinction exists between *mechanic* and *mechanical engineer*.

Note: There has been a tendency in recent years to describe the theoretical or academic basis of engineering as *Applied Science*, especially in areas like *Microelectronics*. Thus a microelectronics expert may regard himself as an *applied scientist* (as distinct from a *pure scientist*: physicist, biologist, etc) rather than an engineer.

7.2 Electrical/Electronic Equipment

The distinction *electrical/electronic* in compounds with *circuitry*, *device*, *capacitor*, *signal* refers more to the applications of the circuitry concerned than any fundamental technical differences. Distinctions concern *power* as well as *current*. Electrical engineers work with *electric motors*, *generators* and other *machinery* involving powers up to the *megawatt* range. Electronic engineers deal with applications from *robots* to *rocket control*, working mostly at the *milli-* or *microwatt* level. Non-native speakers should note that the adjectives *electric* and *electrical* are interchangeable in compounds (British) with *power, energy, field, charge*, but not in the following cases: *electrical machinery; electric motor/dish-washer/guitar*. Alternatives to *electronic* or *magnetic* with *-al* do not exist.

Electrical equipment involves *ac-supplies*, *inductors* and *transformers*; applications include: *voltage regulation* of electrical generators, *speed control* of electrical machinery, *power supply and transmission.* Resistors used in Light Electrical Engineering consist of *strips* of metal (copper, etc) or *wire coils*, and look very different to their counterparts in electronic applications. The terminology is older than that of Electronics: *capacitors* are often called *condensers*; *inductors* are referred to as *chokes*; *wire-wound potentiometers* are termed *rheostats*. The term *engine* does not exist in this field, the German *Elektromotor* being rendered as *electric motor*, or in British English simply as *motor*: *starter motor, windscreen wiper motor, washing machine motor*. There are *dc* generators but engineers designing equipment for households, factories, power stations, work mainly with *ac*. It is therefore advisable for translators in this field to have a firm understanding of *phasor diagrams*, and the distinctions *resistance*, *reactance* and *impedance* discussed in Chapter 2. A brief terminology of *electric motors* and *generators* is given in Fig.7A.

Electronic equipment consists mainly of *circuitry* and *circuit modules* operated from *dc* supplies. *Circuit technology* and the devices involved are the theme of the following sections.

Note: The terms *electrics* and *electronics* have little in common. *Electronics* is an *engineering* discipline, whereas *electrics* is a pragmatic abbreviation for *electrical equipment* and appears in compound terms where the full expression is a little clumsy: *auto-electrics*, *lathe electrics*, *household electrics.* Occasionally, however, this distinction is blurred. For example, a distinction between *auto-electrics* (dashboard, wipers, lighting) and *auto-electronics* (electronic ignition, fuel injection) is currently emerging.

7.3 Circuit Technology

The list of standard electronic circuits is immense and the degree of complexity is often bewildering for a non-technical person. Fig.7B summarises the circuit types most frequently encountered.

Many of these circuits were originally built using *thermionic devices*. By the sixties, however, the technology of semiconductor devices had advanced sufficiently to enable alternative versions to be manufactured which had enormous advantages, particularly in terms of cost. Circuits containing no thermionic devices whatever were referred to as *100% solid-state*. The term *solid-state* came about initially as a layman's term. In thermionic circuits the amateur electronics enthusiast can actually "see" whether electrons are flowing by judging the *glow* in different *tubes*. In *semiconductor* devices this was no longer possible, and the absence of a complex *vacuum-controlled* region gave the transistor a awe of mystery, as the complex regulation processes are carried out within the solid material itself. The expressions *100% solid-state* and *fully transistorised* are near synonyms.

Nowadays, almost all electronic circuitry is solid-state, owing to the greatly reduced manufacturing costs and the often superior performance. Notable exceptions are found in the live-music industry where *tube amplifiers* are preferred in view of the relatively high *audio* power (and hence *electrical power*) requirements. Indeed, the once undesirable *feedback* effects of *tube amplifiers* are now a particular selling feature of many electric guitar amplifiers.

The German *Röhre* appears in many dictionaries as: Am. *tube*, Br. *valve*. This is an over-simplification. British *television sets* contain both *tubes* and *valves*. The *tube* is what the viewer actually looks at (Ge. *Bildschirmröhre*) whereas the *valves* (Röhren) "glow" at the back of the set and are responsible among other things for *amplifying* the *video-* and *audio-broadcast signals*. No distinction occurs in American. *Valve* and *tube* have existed side by side in British technical English for many years but the days of *valve* are numbered. The translator is therefore recommended to follow the practice adopted by the author so far and ignore the electrical term *valve* completely.

The job of an electronic engineer is to design *circuit systems* using the variety of *devices* available. The *passive devices* - resistor, capacitor, inductor are discussed at length in Chapter 2. Similar treatment is given to the *active devices - diode, transistor* and *thyristor,* in the following section.

7.4 Junction Devices

The term *junction device* covers devices made of *semiconductor material* whose operation depends on the effect of a *junction* between material of opposite *doping* (section 5.2.3). There are *junction diodes* (pn), *transistors* (npn, pnp) and a variety of *thyristors* (pnpn). Junction devices are obtainable in many different sizes and *rated* for currents ranging between 1 microamp and approximately 30 amp. *Power diodes* and *power transistors* which are used among other things in the *power stage* of *amplifiers,* the final stage connected directly to the *speaker,* are junction devices. The *field-effect* and *unijunction transistors* (FET/UJT) cannot be used as *power devices,* since their *current rating* is too low.

7.4.1 Diode

A *rectifier* is a device which conducts current in one direction only. An *ideal rectifier* provides zero resistance to current (a *short-circuit*) when the voltage across it happens to be positive, and infinite resistance (an *open-circuit*) when negative. A *diode* is a close approximation to an ideal rectifier but neither of the two states are true *extremes,* true open- or short-circuits. The device "stops" conducting not at zero voltage but at a small value defined by the *contact potential* (Chapter 5). Rather than speak of *positive* and *negative voltages* in the context of diodes it is customary to use the terms *forward* and *reverse bias.* Similarly the terms *short-/open-circuit,* in referring to the *mode* of operation, are replaced by *conducting/non-conducting* mode.

When the *forward voltage* applied to a diode is sufficient to overcome the *contact potential* of the *junction,* the diode is said to be in the *conducting state* or *biased* in the *conducting mode.* Regardless of the *forward current* the *forward turn-on voltage* hardly varies from this value, the latter is therefore a *device parameter*: typically 0.7 V for silicon diodes and 0.3 V for germanium.

Under *reverse bias* the diode acts like an open-circuit until a specific *breakdown voltage* is reached when the semiconductive properties change (typically -50 to -150 V). In the *non-conducting* mode the diode still conducts a minute *reverse current* (a tiny fraction of a microamp), termed *residual* or *leakage* current.

7.4.2 Transistor

Like an *ideal rectifier* (Chapter 6) an *ideal electronic switch* is one which has two *states* corresponding to *short-* and *open-circuit* conditions. Whereas a mechanical switch,such as an ordinary light switch) has to be *flipped* from one state to the other by a person, an electronic switch simply needs a *voltage signal*. *Transistors* can be used as electronic switches.

A transistor can be imagined as two *junction diodes* connected *in series*. Separate currents flow through the two "diodes", one much larger than the other, and the smaller current in the first diode can be used to *control* the larger current in the second diode. It is therefore conceivable that such a device can be used to *amplify* currents or to *switch* them on and off. This is the case for the *junction transistor* (synonym: *bipolar transistor*). The *control current* (the smaller one) enters at the *base electrode*, and modifies (controls) the *collector current*.

The term *junction transistor* covers a large variety of devices of different appearance, each consisting of three layers of semiconductive material. They are distinguished according to their applications: *power transistor*, *switching transistor*, *AF/RF transistor* (audio/radio-frequency), and sub-classes are denoted by complex pragmatic labels, such as *BFX 85 audio transistor*. Other so-called *transistors* - *UJT*, *FET*, *MOSFET* (Fig.6A), have a more restricted range of application and operate differently from the above transistors.

Three sets of *characteristic curves* are generally provided for determining junction transistor parameters : *input*, *output* and *transfer characteristics*. The *input characteristics* of a transistor are curves of base current against base voltage; *output characteristics* concern collector current and collector *voltage* at constant base current; *transfer characteristics* involve curves of collector current against base current at constant collector voltage.

When the base voltage falls below a certain minimum, the *cut-off voltage*, the collector current falls to zero (*cuts off*). Alternatively, when the base current rises above a certain maximum value the collector current cannot increase any further. The transistor *saturates* at a collector-emitter voltage of about 0.2 V, the *saturation* voltage. These parameters are required in the design of *transistor switching circuits*.

For *amplifier* circuits a third parameter is needed : *forward current transfer ratio* (usually called *current gain)*; this corresponds to the ratio of the *amplitudes* of the collector and base currents for small *incremental* changes.

7.4.3 Thyristor

The idea of an *ideal electronic switch* is directly relevant here. The transistor can function as one type of electronic switch: the type rapidly *triggered* by an *electrical signal* from one state into another; it remains in a particular state (eg "ON") only for as long as the *control current* (the *base current*) is maintained at the correct level, and reverts back to the opposite state ("OFF") when the control current changes. This device is useful for many applications, above all in the *multivibrator circuits* of computers, but it is not so appropriate for triggering, for instance, a fire alarm. What is needed in alarm circuits is a switching device which remains in one state after being triggered. Once it is triggered "ON" it should remain "ON". This device is the *thyristor.*

Thyristors are used in conjunction with *transducers* (section 6.3) for a variety of common applications: burglar alarms, dish washers, ovens, and for *overload protection* in certain *electrical equipment*. There are various types of thyristor, distinguished according to the desired *function*: whether they are to provide an *open-* or a *short-circuit* on triggering; whether they are to be reset *electrically* or *mechanically* (by disconnecting and reconnecting).

In view of their diversity, thyristors are not discussed in detail. *Characteristic parameters*, such as *trigger voltage*, *turn-on current*, *reverse voltage* apply in this context, and the electrodes are usually termed *anode*, *cathode* and *gate*. *Selenium rectifiers* (SCR) are a common type of thyristor and employ much the same technical vocabulary.

7.5 Power Supply Unit

Every electronic circuit requires a *dc power supply* of a certain fixed voltage in order to operate or *bias* the respective components. This *circuit bias* may be obtained from *batteries* but usually it originates from the *ac mains*. Thus an electronic *power supply* does not really *supply* power at all. It simply converts the *ac mains voltage* into a *dc voltage* suitable for operating circuitry. The *power-supply unit* of any electronic equipment, including simple radios, cassette recorders and computers, is therefore itself a relatively sophisticated piece of *electronic equipment*, employing transformers, diodes, capacitors, transistors, IC's and other electronic devices.

A *power supply circuit* involves the following operations : *transformation*, *rectification*, *smoothing* and *regulation*. For *tube circuits* the dc voltage level required (200 to 400 volt) may exceed the *mains voltage* (about 240 volt), but for most circuits, including all *solid-state circuits*, the dc voltage is much less. The voltage level is set in the first stage: *transformation*.

Transformation implies the conversion of an ac mains voltage (220 V) into an ac voltage of the required level (eg 25 V) and usually requires only one circuit component, namely a suitable *transformer*.

Rectification concerns the conversion of an *ac voltage* into a *rectified ac voltage*, namely one in which the voltage still varies but the *cycle* always remains *positive* (or always *negative*). Semiconductor diodes are normally used for this purpose. If only one diode is used the result is *half-wave rectification*, where *half* of the original *voltage waveform* is passed on to the next stage, for instance just the *positive cycle*. A suitable configuration of four diodes provides *full-wave rectification*, that is the *negative cycle* of the voltage waveform is converted to a *positive* cycle so that the *full* waveform is passed on.

After the *rectifier* stage follows the *smoothing stage*, where the *rectified ac* voltage waveform is converted into a *dc* "waveform" by means of large *capacitors*. When in use, however, the *load circuit* fed by the *power supply* results in a continuous discharge of the capacitors. The resulting *smoothed rectified wave* may thus be considered equivalent to a *true* dc source with a superimposed ac *ripple*. This *ripple voltage* vanishes when there is no *load* (nothing connected to the power supply) but increases with output current on connecting the load. *Ripples* are responsible for *mains hum*, a steady low-pitched sound characterising many cheap *amplifiers*, *record-players* and very old *radios* from the thirties (so-called *wirelesses*).

A good power supply is one with a low *ripple factor* - the ratio of the ripple voltage to the mean dc voltage is as low as possible, certainly much less than 1%. To attain this, some relatively sophisticated circuitry is required involving primarily *Zener diodes* and a *transistor feedback* system. A power supply providing a *smooth*, *stable* dc output regardless of *load* or *temperature* extremes is said to be regulated.

7.6 Household Electrics

The expression *household electrics* refers to the system of *insulated cables*, *mains sockets*, *mains switches*, *light switches*, *junctions*, etc, installed by an *electrician* in a household, office, school or factory, the so-called *wiring system*. Any household electrical appliance has a *mains lead* (Am. *power cord*) to which a *mains plug* is attached. When the appliance is operated, the lead is inserted (*plugged*) into a *mains socket* (Am. *power socket*), also colloquially referred to as a *plug*. (*The plug is plugged in the plug!*)

Household mains plugs have two or three *pins*. British *3-pin plugs* are *fused*, that is contain *fuses* designed to *blow* when a certain current is exceeded. 3A- and 13A-fuses are usual. Fuses consist of tiny sections of delicate *wire* designed to break when the temperature of the wire due to the current conducted becomes excessive. British mains sockets are separately fused, namely *wired* to fuses in the *fuse-box* adjacent to the *electricity meter*. The colloquial usage of the verb *fuse* is different to that of *fused socket* above, and implies that "a fuse has blown", for instance: "The lights have *fused*". Fuses are employed inside televisions, video recorders, hi-fi systems, etc to avoid destruction of delicate circuitry. Such fuses are smaller than *mains fuses* and *blow* between 1 mA and 1 A.

German and American household wiring systems are not fused but employ instead a system of *cut-outs*, small automatic switches operated electrically by *relays* or other electrical devices which *flip* the switch in the event of an *overload*. Cut-outs are employed in household appliances, when the appliance itself is less delicate or the possibility of death by *electrocution* is more remote. In such cases *push-button cut-outs* are common, which are depressed when the overload has been removed.

7.7 Auto-Electrics

Automobile Electrical Systems or simply *Auto-Electrics* involve devices operated at low voltages (usually 12 volt) with currents of up to about 30 A. Various circuits for the *ignition*, *lighting*, *dashboard meters* (syn. *instruments*), etc, are separately *fused*. The fittings and accessories, mainly *lamps* and *meters*, are relatively unsophisticated and usually consist of *sealed units* which are simply changed by the auto-electrician when a defect occurs. The same applies to complex items, such as *electronic ignition* or *fuel injection systems*. This section discusses the characteristic parameters of various electrical components of the conventional automobile. Similar devices, such as *battery*, *motor*, *generator*, *regulator*, are found in other areas of electrical engineering employing low-voltage dc machines.

Batteries are characterised by their *capacity*, a parameter providing a measure of the total *charge* contained. *Capacity* is measured in *amp-hour*, a unit easily converted into the standard SI unit *coulomb*. It has nothing to do with *capacitance* (Chapter 2), which is measured in *farad*. Apart from *battery voltage* the main parameter indicating the condition of the battery is the *specific gravity* of the battery acid (Ge. *Säuredichte*).

The *starter motor* or simply *starter* is a sophisticated device consisting of an *armature* rotating between two *field windings*. Current from the battery flows into the *windings* and sets up a *magnetic field*. It also flows into the *armature* via a *commutator* and *brushes*, and the effect of the *current-carrying conductors* in the magnetic field causes the armature to rotate. The armature is connected to the *engine flywheel* via a *drive pinion* and provides the initial *rotational momentum* for the engine to *start*: to *fire* and continue *running*.

Starter motors are characterised mainly by the *configuration* of the field windings and by the *maximum current draw* (the battery current) which may exceed 400 A. Since it is difficult to *switch* currents of this magnitude by conventional methods an *electromagnetic switch*, a so-called *solenoid*, is connected between the dashboard ignition switch and the starter.

The *power* or strictly speaking *charge* taken from the battery when starting the engine is replaced by the *generator* at the rate of about 30 amp when the engine is running. *Dynamos* were the first type of *generator* and operate in the reverse manner to *starters*: an armature moving in a magnetic field provides a current, instead of current providing motion. Most modern vehicles have *alternators*, devices which unlike *dynamos* provide a high current even at low *engine speeds*, as in heavy traffic. The terms *dynamo* and *alternator* are not common in American (see Fig.8A).

Current for other items of electrical equipment - *ignition*, *lighting*, *wipers*, etc, is also provided by the generator and battery but in conjunction with a device known as a *regulator*. Like the *regulator circuits* of dc power supplies (section 7.5) this device provides a constant *circuit bias* (about 13.5 volt) and ensures that the battery current does not become excessive, so that battery is not *overcharged*. It operates rather like a *relay* and disconnects the *generator voltage* when certain limits are exceeded.

Figure 7A: Electric Motors

1	motor	Elektromotor
11g	dc motor	Gleichstrommotor
12g	ac motor	Wechselstrommotor
121g	three-phase motor	Drehstrommotor
1211g	synchronous motor	Synchronmotor
1211a	three-phase mains	Dreiphasennetz
13p	field winding	Feldspule
131a	magnetic flux	magnetischer Fluß
1311m	flux density	Flußdichte
1312m	induced emf	Induktionsspannung
1313m	rate of change	Änderungsgeschwindigkeit
14p	commutator	Kommutator
15p	carbon brushes	Kohlebürsten
16m	speed	Drehzahl

Figure 7B: Circuit Applications

1	Amplifier Circuit: entertainment
11g	Pre-Amplifier: small voltage-signal amplification
111g	Voltage Amplifier: audio-/radio-/video-signals
112g	Current Amplifier: cybernetics
12g	Power Amplifier: loudspeakers
2	Switching Circuit: computer hardware
21g	Logic Gate: digital processing
211-5g	AND-,OR-,NAND-,NOR-,NOT-Gate
22g	Multivibrator: digital computing
221g	Astable Multivibrator: digital timing
222g	Bistable Multivibrator: binary counter
223g	Monostable Multivibrator: pulse-shaping
23g	Register: digital memory

3	Oscillator Circuit: entertainment
31g	Continuous Oscillator: electronic organ
32g	Local Oscillator: TV-,radio-tuner
4	Receiver: radio-,TV-reception
41p	Tuner: selection of broadcast signal
42p	Demodulator: extraction of signal information
43p	Filter: reduction of electromagnetic interference
44p	Suppressor: suppression of local interference
5	Comparator Circuits: electronic control
51g	Voltage Comparator: machine speed regulation
52g	Current Comparator: electrical load distribution
6	Measurement Circuits: device parameters

Figure 7C: Power Supply/Circuitry

1	power supply	Stromversorgung
11g	mains source	Netz
111m	mains voltage	Netzspannung
1111a	voltage cycle	Spannungsperiode
12g	dc power supply	Netzgerät
121a	transformation	Umspannung
122a	rectification	Gleichrichtung
123a	regulation	Stabilisierung
124m	output voltage	Ausgangsspannung
125m	ripple voltage	Brummspannung
126m	internal resistance	Innenwiderstand
2	electronic appliance	Elektrogerät
21p	power unit	Netzteil
211p	fuse	Schmelzsicherung
212m	circuit bias	Betriebsspannung

22p	circuitry	Schaltungen
221p	amplifier	Verstärker
2211g	pre-amplifier	Vorverstärker
2212g	power amplifier	Leistungsverstärker
2213g	audio amplifier	NF-Verstärker
2214a	interference	Störungen
222p	tuner	Tuner
2221a	waveband	Wellenbereich
22211g	medium waveband	Mittelwellenbereich
223p	receiver	Empfänger
2231a	reception	Empfang
224p	suppressor	Suppressor
2241a	interference suppression	Entstörung
2242p	filter	Filter
225p	transmitter	Sender
226p	oscillator	Oszillator
2261p	resonance circuit	Schwingkreis
227a	rating	Dimensionierung

Chapter Eight

AUTOMOTIVE ENGINEERING

Unlike some of the basic concepts of other areas covered so far, those of Automobile Technology are likely to be at least familiar to even the most "non-technical" linguists. Not all translators would recognise a *thyristor*, when they see one, but most people would know what an *engine* or *gearbox* looks like, and what they consist of. Descriptions in this chapter are therefore brief, and primarily concern technical terminology rather than concepts.

Automobile Engineering originated in the days of skilled craftsman as an extension of Mechanical Engineering. It now employs many sophisticated electrical and electronic devices and production plants make much use of *robot technology*. Hence, the terminologies of all fields covered so far (except Nucleonics) are relevant to a certain degree here, together with occasional vocabulary of Chapter 9 - *hand tools*, *metal properties*, etc. *Automotive*, employed in the title above, is a global term covering all aspects of *motor vehicles* (engine, body, tyres, etc). One sub-field of Automotive Engineering which employs the talents of *electrical* rather than primarily *mechanical engineers* is dealt with in Chapter 7, namely Auto-Electrics.

In view of the thriving automobile industries of the German-speaking countries and the associated industries - *car shampoo*, *dashboard fittings*, *fog lamps*, *lubricants*, *underseal sprays*, etc, this is an important field for translators. The role of electronics in the automobile industry is increasing all the time and reliable *electronic ignition* and *fuel injection systems* have been on the market since the early seventies. Despite the brief descriptions of this Chapter, the field has not been neglected. Fig.8A-E contain a substantial basic vocabulary of Automotive Engineering alone. Many other relevant concepts occur in Chapters 1, 2, 6, 7, 9-11.

The terminology of Fig.8B-E is arranged in the form of systematic hierarchies. If the reader has not already glanced at the Chapter 12 and acquainted himself with the interpretation of the various *logical* and *ontological descriptors - g/p/m/a,* if might be helpful to do so now. Readers who are completely unfamiliar with any automobile concepts discussed can obtain rough definitions from the hierarchies themselves. Thus, the concept *bob weight* (Fig.8B, 134p) can be interpreted as "part of a *distributor* (13) together with other parts: *vacuum unit* (133), *distributor housing* (135), *spindle* (131), *contact breaker* (132)". Similarly *distributor* is "part of an *ignition system"*, and *coil/condenser* are "terms used in the context of *conventional ignition* systems". Indeed, there is more information about automobiles in these *hierarchies* than in the *text* of this Chapter. Newcomers to this area of translation are therefore recommended to study the hierarchies closely, consult *repair manuals* for their own particular vehicles, and try to visualise each individual concept.

An remark is appropriate here on the topic of polyonyms resulting from different terminologies in the British- and American-English-speaking countries. Just as a British housewife is confused by the American usage of words like *biscuit*, *jelly*, *faucet*, so a British automobile mechanic hesitates when an American customer complains of trouble with his *sway bar*, *muffler* or *battery ground*. Automotive Engineering is not an area where differences between British and American usage are negligible. The industries grew up independently in the countries concerned and, since many of the concepts have become general everyday vocabulary, such as *engine/motor*, *boot/trunk*, *windscreen/windshield*, attempts to achieve conformity in the terminologies are repeatedly frustrated. Fig.8A provides a list of the most common but "least technical" concepts which are named differently by British and American automobile specialists; the list is "trilingual" for the benefit of German readers.

The hierarchies of Fig.8B-E contain British terminology; different American terms are mentioned in the Chapter. Trivial variations (such as *spark/sparking plug*, *bleed/bleeding nipple*), even within British English, are ignored. The "terminologies" of different automobile manufacturers operating in the same country or even in the same town often vary considerably owing to internal company policy or to technical differences in the vehicles themselves.

8.1 Ignition System

The components of both the *ignition* and *fuel systems* are usually not manufactured by the automobile companies themselves but by smaller specialist concerns (Bosch, etc). Many companies encourage the individual *mechanic* "to replace *units* as a whole" - the *distributor, carburettor, fuel pump,* etc, but their *fitting instructions* contain descriptions of the individual parts. The translator therefore needs to acquire a rough understanding of the units concerned, perhaps by carrying out his own car repairs for a while.

Ignition systems are divided into two rough categories: *conventional* and *electronic ignition*. In the conventional system the *spark* is provided by the rapid *charging* of a simple *capacitor* (usually called *condenser* in this field) through the *primary winding* of a *transformer*. This generates a high *voltage* (about 30 kV) in the *secondary winding* for a brief period, which eventually creates a *spark* at the *electrodes* of one of the *spark plugs*. The *transformer* is enclosed in a sealed *case*, which is accessible via specific *terminals*, still regretably called *LT* and *HT terminals*. *LT/HT* originally stood for *high/low tension*; the term *electrical tension* (meaning *voltage*) is now completely obsolete, even in this field, but the abbreviations *LT/HT* persist. The complete transformer unit - the *core, windings, case* and *terminals* is referred to collectively as the *coil* (syn. *ignition coil*; Ge. *Zündspule*). This designation is a *misnomer*, in both English and German, since *coil* here refers to a *transformer*, rather than the usual meaning *inductor* (Chapter 2).

Electronic ignition systems are of many different types and use the full range of electronic devices: *diodes, transistors, thyristors, resistors,* but not *tube components*. With few exceptions they produce the spark by *capacitative discharge*, where the *spark energy* is provided by an elaborate technique involving *charge storage* in special *capacitors* instead of employing *magnetic energy* resulting from the *primary current* in the *ignition coil*. Generally speaking, electronic ignition systems are capable of providing a higher and more powerful *spark* under less favourable conditions (deficient *spark electrodes, damp distributor cap, discharged battery*) than the conventional system.

The terminology of the *distributor* is relatively straightforward. The spark is triggered by the *contact breaker* and passed to the appropriate *ignition lead* (syn. *HT-lead*) via the *rotor*. The *timing* of the spark is a mechanical operation carried out when the distributor is installed; fine adjustments to suit the driving conditions (motorway-, hill-, town-driving) take place automatically via the *centrifugal weights* and the *vacuum unit*.

8.2 Fuel System

The *fuel system* consists of a *tank*, *pump* and *carburettor*, and the various *feed pipes* between the units. The strict term *pipe* is used when the object concerned is *rigid* and *metallic* (usually *aluminium*); *hose* covers the *flexible* (rubber) *tubing* which connect the *pipes* to the various components. The same distinctions occur for the *brake system* - *brake pipe, brake hose*, and for other areas: *radiator hose, vacuum hose, ventilation pipe* (fuel tank). The term *lines* covers pipes, hoses and other connections, but it is normally only used in the plural as in *fuel lines, brake lines.*

Connection is slightly ambiguous here. It implies the German *Verbindung* in: *connection hose, connection pipe, connection unit*, but can also be translated by *Anschluß*. Technologists avoid confusion by employing *connection* for the former meaning and *union* for the latter; hence *fuel-pipe union, brake union*.

The *fuel pump* is responsible for transferring the fuel from the *tank* to the *carburettor*, where the correct *air/fuel mixture* is obtained by *atomising* the fuel, namely making a fine vaporous cloud using a current of air. From there the *fuel* enters the *inlet manifold* of the *engine* and finally the *cylinders*. There are two types of fuel pump: *mechanical* and *electrical*. Both types contain a *fuel chamber* and a *diaphragm* for pumping the fuel from the tank to the carburettor, as well as a *filter* for collecting the *tank deposits* (dirt, flakes of metal, etc). They differ only in the *pump mechanism*, which is operated either by a *lever* connected to a *cam* inside the engine, or by a device connected electrically to the vehicle battery.

There are different types of *carburettor*. Many contain a *fuel chamber* filled via a *needle valve* which *cuts off* when a hollow brass *float* at the fuel surface reaches a certain level; the term *fuel chamber* is then replaced by *float chamber*. The fuel is forced through *jets*, tiny apertures of less than a millimetre *bore* (internal diameter), into the *throttle chamber*, where it is mixed with air taken in via the *air filter* unit (synonym: *air cleaner*). The *fuel intake* of the engine is controlled by a *throttle*, a rotatable disc (the *throttle plate*) operated via a *cable* connected to the *accelerator pedal*. Some carburettors have several *jets* others have one *main jet* and control the *mixture* by different methods. Certain vehicles, particularly sports cars have more than one carburettor - different ones for different *engine cylinders*; hence the terms *twin-/multi-carburettor system*.

The term *fuel* in this area is the general one covering *petrol, diesel, methane gas, alcohol* or any other *combustible substance* used to drive an engine. In terms like *petrol pump, petrol feed, diesel tank*, the terms *petrol/-diesel* are simple substitutions for the collective term *fuel*. *Fuel* is also used in *repair manuals* to imply *fuel/air mixture* but here it is not usual to substitute *petrol*, etc. When the *mixture* contains a higher *fuel/air ratio* than normal it is said to be *rich*; a *weak mixture* is when the air proportion dominates. *Choke* and *throttle* are not synonymous here. The *choke system* is operated via a *cable* from the *dashboard* or *steering column* and causes a *rich mixture* when starting the engine from cold. The *throttle* controls the *fuel intake* - the rate of flow of *fuel* (fuel/air) into the engine, and is operated by a cable connected to the *accelerator pedal*. *Choke* and *throttle* are also used as verbs.

The *mixture* is set externally by means of an *adjuster screw*, the so-called *mixture screw*. The *throttle setting* when the engine is *idling* (running, but without the vehicle moving) can be adjusted via an *idling screw* (contextual synonym: *throttle stop screw*). The combined process is referred to as *carburettor tuning*, as distinct from *ignition tuning* - setting the *dwell angle, firing point, spark electrodes*, and *engine tuning* which covers *valve timing* and *valve rocker* adjustments.

8.3 Engine, Transmission

The operation of the classical *four-stroke engine* is well known. A rotating *crankshaft* operates four *pistons* which are arranged to move up and down alternately, such that at any instant each *cylinder* is subjected to one of the four *stokes*: *inlet*, *compression*, *firing*, *exhaust*. At one end of the crankshaft there is a large, relatively heavy disc, known as the *flywheel*, which conserves *momentum* and helps the engine to rotate smoothly between *strokes*. The other end of the crankshaft is connected to a *pulley* which drives certain other *parts*, such as the *generator*, *water pump* or *cooling fan* by means of a *V-belt* (contextual synonym: *fan belt)*; the subscript *V-* refers to the cross-sectional shape of the belt, a "V-shape".

Inside the engine, the crankshaft is mechanically connected to a second shaft, the *camshaft*, which is responsible for the operation of the *valves* and other parts, such as the *distributor* and *fuel pump*. *Chain-drive* is normally employed between the two shafts, rather than *belt-drive*. The *chain* directly controls the *valve timing*, and indirectly also the *ignition timing*; hence the term *timing chain*. The engine is started by means of a *dc electric motor*, the so-called *starter motor* (synonym: *starter*), which *meshes* into the *flywheel*. The starter is operated via a special *magnetic switching device*, the *solenoid*, connected electrically to the vehicle *battery* and to the *ignition switch*.

The *flywheel drive* (synonym: *engine drive*) is connected via *frictional plates* (the *clutch*), to the *gears* (automatic or manual) and from there, via a system of *drive shafts* with interlocking *worm-gears*, to the *axles* of the *road wheels*. The *drive shafts* vary according to whether the vehicle has a *front* or *rear engine* and *front-* or *rear-wheel drive*. Early vehicles had front engines with rear-wheel drive via *differential gearing*. One of the first *rear engines* (also the first *air-cooled engine*) appeared in the late thirties in the classic German Volkswagen, and the first *front-wheel drive* was employed in the late fifties in the British Mini.

Front engines with front-wheel drive are now standard in many small vehicles. Since, for technical reasons, it is convenient to arrange the *engine drive* not along the *axis of symmetry* of the vehicle but *transversely*, in other words along the *axis* of the *front axle*, the term *transverse engine* (synonym:

transverse-mounted engine) occurs in this context. The German reader should note the different translations of the mechanical term *Achse* (axle) to that of the mathematical one (axis).

8.4 Brake System

Early vehicles had *mechanical brake systems*. *Pedals*, *levers*, and other *controls* accessible to the driver for applying the vehicle brakes were connected to the road wheels via a system of *cables*, *rods* and *linkages*. Today only the *handbrake system* (Am: *parking brake*) is operated mechanically. The *pressure* of the *footbrake* pedal is transmitted to the road-wheel *brake assemblies* by a *hydraulic system*.

The hydraulic system (synonym: *brake hydraulics*) consists of a *master cylinder*, various *brake pipes*, *brake hoses*, *brake unions* (the *brake lines*; section 8.2) and the *wheel cylinders* of each *wheel drum assembly*. The master cylinder contains a *piston* (syn. *plunger*) connected to the *brake pedal*, which attempts to compress the *fluid* when the pedal is depressed. This results in the pressure being transmitted through the *brake lines* to the *wheel-cylinder pistons*. The fluid itself is poured into a *reservoir* in the master cylinder; provided there are no *leaks* in the system (corroded brake pipes, perished rubber seals, faulty unions, etc) the *fluid level* should remain constant. The fluid is *drained* (syn. *bled*) by means of *bleed valves* (synonym: *bleed nipple*) and must be *topped up* and *re-bled* until all air bubbles are removed, a process termed *brake bleeding*. Air bubbles are compressible and therefore adversely affect the *braking efficiency*.

The brakes themselves are of two main types: *drum brakes* and *disc brakes*. In the case of drum brakes the wheel cylinder pistons force a pair of *brake shoes* towards the inside surface of a rotating *drum* bolted to the road wheel. Each *shoe* consists of a metal *web* to which a *brake lining* is stuck or riveted; when the lining engages with the drum the resulting friction causes the road wheel and hence the vehicle to slow down. *Disc brakes* operate in a similar manner except that here the fluid is forced into a *caliper unit*, a "saddle-shaped" device which grips a *brake disc* attached to the wheel axle.

For safety reasons, most vehicles have separate *hydraulic circuits* for the front and rear wheels, so that in the event of *brake failure* in one circuit the vehicle can still be retarded by the brakes of the other pair of wheels. This is known as a *tandem system* (syn. *dual-circuit system)*; the terms *tandem master cylinder*, *tandem circuit*, *tandem hydraulics* also occur. *Braking power* is improved by the inclusion of a *servo-unit* (contextual synonyms: *booster*; *brake booster*) which increases the *brake pressure* applied to the pedal; the device is a *standard fitting* on heavy cars and an advisable *optional extra* for invalid or women drivers. The hydraulic system includes a hydraulically operated *brake switch* for the rear brake lights, and *monitor switches* connected to *dashboard bulbs* which warn the driver of a leak in one of the brake circuits.

Heavy vehicles, cranes, lorries (Am. truck), buses, etc have a third type of braking system not discussed here: *pneumatic brakes*.

8.5 Steering, Suspension, Bodywork

All motor vehicles, apart from certain farm tractors, cranes, etc, have a *steering wheel* connected to a *shaft* inside an arrangement known as the *steering column*. The shaft is connected to the *steering gear*, a convenient arrangement involving two mechanical devices a *rack* and a *pinion*. The *rack* transmits the *torque* applied at the *steering shaft* to the *tie-bars* connected to the *road wheels*. Vehicles with front *transverse engines* have a different arrangement of tie-bars from those with *conventional engines* and/or *rear-wheel drive*. For details the reader is recommended to consult *manuals* of different vehicles. Maintenance of the *steering assembly* consists mainly of *greasing* the *ball-joints* - the connections between the various *steering bars*, and *oiling* the *steering gear* which is housed in a unit known as the *steering box*.

Note: The Constructional Engineering expressions *tie/strut* mentioned in section 1.4.4 reappear in this field in *tie-bar*, *support strut* and other terms.

The *body* of a motor vehicle is mounted on a strong metal *chassis* which distributes the vehicle and engine weight and transmits it to so-called *subframes*. The *subframes* are mounted on the *axle tubes* (of the *road-wheel axles*) by a system of *suspension springs* and *support arms*. The bodywork itself is *suspended* rather than simply *supported*, in order to compensate for bumps in the road and enable the driver to have a "smooth ride". The *suspension assemblies* at both the front and rear of the vehicle usually employ *coil springs*; *leaf springs* are employed at the rear. *Shock absorbers* attached to the road wheel axles improve the driving comfort still further. So-called *track-control arms* control the *front-wheel alignment* (synonym: *tracking)*; correct tracking reduces uneven wear on the *tyre tread*. Any lateral "rocking" of the vehicle is compensated by the *stabiliser bar* (near-synonym: *anti-roll bar*; Am. *sway bar*). Like the *steering rods*, the *joints* of the various *track control* and other *arms* are equipped with *grease nipples* for regular *lubrication* using *grease guns*.

The *body* of a motor vehicle is usually sprayed with various *rust-protection compounds* at the factory or plant before being mounted on the *chassis*. After this has taken place the entire underneath of the vehicle, the so-called *underbody* is sprayed with an appropriate *underseal compound* for rust protection against the weather, salt or grit. Before the vehicle is finally assembled, the *body*, *doors*, *wings* (near synonym: *mudguard*) and *bonnet/boot lids*, all of which constitute the *bodywork*, are sprayed with special paints. After this stage the terms *bodywork* and *paintwork* are near synonyms and contrast with *chromework* - *bumpers* (Br.), *door handles* and *locks*, *rubberwork* (door/window *seals*) and the *woodwork* of certain luxurious limousines.

There is still a fair amount of "terminological rivalry" between car manufacturers in British- and American-influenced countries, particularly in the every-day concepts: *wing/fender*, *petrol/gas*, *boot/trunk*, *windscreen/windshield*. But the number of American "movies" (shown unedited in Britain) and the current decline of the British automotive industry is likely to swing the balance early in the next century ultimately in favour of American. British automobile terms are kept alive at the moment not so much by the British themselves as by French, German, Italian, Japanese and even American automobile concerns eager to exploit the British market.

Figure 8A: Automobile Terms, British/American/German

accelerator pedal	gas pedal	Fahrpedal
alternator	ac generator	Wechselstromlichtm.
anti-roll bar	sway bar	Querstabilisator
bonnet	hood	Motorhaube
boot	trunk	Kofferraum
carburettor	carburetor	Vergaser
circlip	snap ring	Sicherungsring
dynamo	dc generator	Gleichstromlichtm.
earth	ground	Masse
float chamber	float bowl	Schwimmergehäuse
gear-change	gear-shift	Gangwechsel
handbrake	parking brake	Handbremse
hood	soft top	Cabrio-Verdeck
indicator	turn signal	Blinker
motorway	freeway	Autobahn
petrol	gasoline	Benzin
petrol tank	gas tank	Tank
reverse gear	back-up gear	Rückwärtsgang
roof rack	car-top carrier	Dachgepäckträger
side light	parking light	Standlicht
silencer	muffler	Auspufftopf
spanner	wrench	Schraubenschlüssel
split pin	cotter pin	Splint
oil sump	oil pan	Ölwanne
tyre	tire	Reifen
vice	vise	Schraubstock
windscreen	windshield	Windschutzscheibe
mudguard	fender	Kotflügel

Figure 8B: Ignition/Carburation/Battery

1	ignition system	Zündanlage
11g	electronic ignition	elektronische Zündung
12g	conventional ignition	Normalzündung
121p	condenser; capacitor	Kondensator
122p	coil	Zündspule
1221p	primary winding	Primärwicklung
1222p	secondary winding	Sekundärwicklung
13p	distributor	Zündverteiler
131p	spindle; shaft	Verteilerwelle
1311p	cam	Nocken
132a	contact breaker	Unterbrecherkontakt
1321p	contacts	Kontakte
13211p	contact face	Kontaktfläche
1322m	contact breaker gap	Kontaktabstand
13221m	dwell angle	Schließwinkel
1323a	contact set	Unterbrechersatz
1324a	base plate	Unterbrecherplatte
133p	vacuum unit	Unterdruckdose
134p	bob weight; centrifugal w.	Fliehgewicht
135p	distributor housing	Verteilergehäuse
136p	rotor	Läufer
137p	distributor cap	Verteilerdeckel
1371p	ignition lead; HT-lead	Zündkabel
1372a	spring clip	Federspange
14p	spark plug	Zündkerze
141a	firing order	Zündfolge
142p	electrode	Elektrode
142m	electrode gap	Funkenstrecke
2	fuel system	Kraftstoffanlage
21p	fuel tank	Kraftstofftank
211m	capacity	Tankinhalt
212a	ventilation pipe	Entlüftungsleitung

213a	fuel sensor	Kraftstoffgeber
2131a	fuel gauge	Kraftstoffuhr
22p	feed pipe	Kraftstoffleitung
23p	fuel pump	Kraftstoffpumpe
231p	fuel filter	Kraftstoffsieb
232p	pump chamber	Pumpengehäuse
2321p	diaphragm	Membrane
2322p	inlet valve	Saugventil
2323p	outlet valve	Druckventil
233m	delivery pressure	Förderdruck
24p	carburettor	Vergaser
241p	needle valve	Nadelventil
242p	float chamber	Schwimmergehäuse
243p	float	Schwimmer
244p	jet	Vergaserdüse
245p	throttle plate	Drosselklappe
2451a	throttle rod	Drosselklappenwelle
246p	adjuster screw	Einstellschraube
2461g	stop screw	Anschlagschraube
2462g	mixture screw	Gemischregulierschraube
2463g	idling screw	Leerlaufeinstellschraube
25p	air cleaner	Luftfilter
251p	filter element	Filtereinsatz
252m	air intake	Ansaugluftmenge
26p	cable	Drahtzug
261p	accelerator cable	Gaszug
262p	choke cable	Choke-Zug
28m	fuel feed	Kraftstoffzufuhr
3	battery	Batterie
31p	battery acid	Batteriesäure
311m	specific gravity	Säuredichte
3111a	hydrometer	Säureheber
312m	acid level	Säurestand
3121a	stopper	Batteriestöpsel

32p	battery terminal	Batteriepol
321g	positive terminal	Pluspol
322g	negative terminal	Minuspol
323a	terminal clamp	Batterieklemme
33m	capacity	Ladekapazität
34m	state of charge	Ladezustand
35a	battery charger	Ladegerät

Figure 8C: Engine/Transmission

1	engine	Motor
11m	engine performance	Motorleistung
111g	peak performance	Maximalleistung
12m	engine speed	Drehzahl
121g	idling speed	Leerlaufdrehzahl
13p	engine block	Zylinderblock
131p	cylinder	Zylinder
132p	piston	Kolben
1321p	piston ring	Kolbenring
1322p	piston rod	Pleuelstange
1323m	piston stroke	Kolbenhub
133a	crankcase	Kurbelgehäuse
134p	crankshaft	Kurbelwelle
1341p	pulley	Riemenscheibe
135p	flywheel	Schwungrad
136p	sump	Ölwanne
137p	camshaft	Nockenwelle
138p	timing chain	Nockenwellenantriebskette
14p	cylinder head	Zylinderkopf
141p	spark plug port	Zündkerzenbohrung
142p	valve port	Ventilbohrung
143p	valve	Ventil
144p	pushrod; tappet rod	Stößel
145p	rocker shaft	Kipphebelachse

1451p	valve rocker	Kipphebel
146p	rocker cover	Zylinderkopfdeckel
2	ancillary component	Zusatzteil
21	oil pump	Ölpumpe
22	water pump	Wasserpumpe
23	fuel pump	Kraftstoffpumpe
24	carburettor	Vergaser
25	distributor	Zündverteiler
26	starter	Anlasser
27	generator	Lichtmaschine
28	V-belt; fan belt	Keilriemen
3	transmission	Getriebe
31p	clutch	Kupplung
311p	pressure spring	Druckfeder
312p	lining	Reibbelag
32p	gearing; gears	Getriebe(-Anordnung)
321g	automatic gears	Automatik
322g	manual gears	manueller Gangwechsel
3221a	gear-lever	Schalthebel
323a	gear-box	Schaltwerk
3231p	gear	Getrieberad
3232	gear-box housing	Getriebegehäuse
33p	driveshaft	Antriebswelle
34p	differential assembly	Differential
341p	differential gears	Differentialgetriebe

Figure 8D: Brake Assembly

1	handbrake assembly	Parkbremse
11p	handbrake lever	Handbremshebel
12p	cable trunnion	Seilhalter
13p	handbrake cable	Bremsseil
14a	cable guide	Seilführung
15p	brake actuating lever	Bremsdruckstange
141p	clevis	Gabelkopf
142p	clevis pin	Splintbolzen
2	footbrake assembly	Bremsanlage
21p	hydraulic system	hydraulische Bremsanlage
211g	single system	Einkreis-Bremsanlage
212g	tandem system; dual s.	Zweikreis-Bremsanlage
213p	brake booster	Bremskraftverstärker
22p	brake pedal	Bremspedal
221a	push-rod	Stößel
23p	master cylinder	Hauptbremszylinder
231p	reservoir	Vorratsbehälter
2311m	fluid level	Flüssigkeitsstand
232p	piston	Druckkolben
24p	fluid lines	Bremsleitungen
241p	brake hose	Bremsschlauch
242p	brake pipe	Bremsleitung
243p	brake union	Bremsanschluß
25p	brake fluid	Bremsflüssigkeit
26p	brake	Bremse
27a	braking efficiency	Bremswirkung
271a	braking power	Bremskraft
3	drum brake	Trommelbremse
31p	brake drum	Bremstrommel
32p	brake shoe	Bremsbacke
321p	brake lining	Bremsbelag

323a	return spring	Rückzugfeder
324a	retaining spring	Ankerfeder
33p	brake adjuster	Bremseinsteller
34p	wheel cylinder	Radbremszylinder
341p	piston	Bremskolben
342p	bleed nipple; bl. screw	Entlüftungsschraube
343p	seal	Dichtung
3431g	piston seal	Kolbenmanschette
3432g	dust seal	Staubschutzkappe
344p	cylinder boss	Zylindergehäuse
35p	brake backplate	Bremsträgerplatte
4	disc brake	Scheibenbremse
41p	brake disc	Bremsscheibe
42p	brake pad	Bremsklotz
43p	brake piston	Bremskolben
44p	caliper	Bremssattel

Figure 8E: Steering/Suspension/Body

1	steering assembly	Lenkung
11p	steering wheel	Lenkrad
12p	steering column	Lenkrohr; Lenksäule
121p	steering shaft	Lenkspindel
122p	steering coupling	Lenkungskupplung
13p	damper	Lenkungsdämpfer
14p	rack	Zahnstange
141a	pinion	Trieb
15p	tie-bar; tie-rod	Spurstange
2	suspension	Aufhängung; Federung
21a	shock absorber	Stoßdämpfer
22p	suspension spring	Aufhängefeder
221g	coil spring	Spiralfeder

222g	leaf spring	Blattfeder
23p	trailing arm	Traghebel
231a	track-control arm	Spurstange
24a	anti-roll bar	Querstabilisator
25a	supporting axle	Tragachse
251g	front axle	Vorderachse
252g	rear axle	Hinterachse
26p	joint	Gelenk
261p	grease nipple	Schmiernippel
27a	tow bar	Schleppstange
3	body; bodywork	Karosserie
31a	chassis	Fahrgestell
311p	subframe	Nebenrahmen
32a	paintwork	Lackierung
321a	metallic finish	Metall-Lackierung
33a	chromework	Chromteile
34a	window	Scheibe
341g	side window	Seitenscheibe
342g	front windscreen	Frontscheibe
343g	rear windscreen	Heckscheibe
344a	tinted window	getönte Scheibe
345a	laminated glass	Verbundglas
346a	demister; defroster	Scheibenheizung
35a	seat	Sitz
351g	reclining seat	Liegesitz
352p	seat back	Sitzlehne
3521a	collapsible seat	umklappbare Sitzlehne
353p	head rest	Kopfstütze
36a	sliding roof	Schiebedach
361g	sunshine roof	Panorama-Dach
37a	mudguard	Kotflügel
371p	mudflap	Schmutzfänger
38a	interior; cab	Fahrzeuginnenraum
381a	carpeting	Bodenabdeckung

Chapter Nine

MECHANICAL ENGINEERING

The terminology of Chapters 1-8 cover the basic concepts common to many areas of technology, with reference to global fields, such as Materials Science, Electronics, Automobile Engineering and Nuclear Technology. Much of the fundamental vocabulary of other areas, such as Mechanical, Chemical and Computer Engineering, has also been covered but not explicitly. The remaining Chapters cover these fields and help to complete the reader's broad conception of modern industrial technology. This Chapter is devoted to Mechanical Engineering. It is divided into four sections headed *Machine Technology*, *Civil/Construction Engineering*, *Nautical/Aeronautical Engineering* and *Metallurgy*.

Whereas a *machine technologist* will happily refer to himself as a *mechanical engineer*, the same is not necessarily true of the other professions, owing to the fact that Mechanical, Civil and Aeronautical Engineering are separate university disciplines and different industrial areas. Nevertheless, each of these fields stems from the branch of *Physics* known as *Classical Mechanics* and their basic terminologies are closely related.

Mechanics is divided into three subdisciplines: *statics*, *kinematics* and *dynamics*. *Statics* covers *forces* acting upon *bodies* in a state of *equilibrium* (bridges, cables, support walls, etc) and underlies modern Civil Engineering. *Kinematics* concerns the effects of relative motion of one body with respect to another irrespective of forces, and now constitutes the basis of the technology of *gear systems*, *cams*, *linkages* and other aspects of *drive machinery*. *Dynamics* deals with the *production* of rectilinear, circular and other motion by the *application* of forces. It underlies both *reciprocating* *engines* (petrol or steam engines, etc) and the *jet engines* of Aeronautical Engineering or Space Technology. The vast field of Mechanics hinges upon just three *Laws* formulated by Isaac Newton more than three hundred years ago.

Metallurgy concerns the *mechanical* and *thermal* properties of metals and alloys used throughout technology. It is related to *Materials Science* rather than Mechanical Engineering itself.

9.1 Machine Technology

Mechanical engineers design and construct *machines*, *engines*, *turbines*, *drive systems*, *lifting gear*, and *mechanical equipment* for specific applications in other branches of technology or industry. The subfield of Mechanical Engineering responsible for the *machinery* used in industrial manufacturing, process engineering, factory workshops, etc is termed Machine Technology.

Machine technology includes the design of workshop machines used as *tools* in manufacturing the components of other machines, such as *lathes*, *drills*, *grinding*, *broaching*, *planing* and *milling machines*. Such machines should perhaps be called "tool machines" (Ge. *Werkzeugmaschinen*) but the standard term is *machine tool*. The use of machine tools to manufacture intricate components of *machines*, *engines*, *gear assemblies*, *linkages*, individually is termed *metal-working*. The *metal worker* begins with a piece of metal of the appropriate material and finally produces *cogs*, *gears*, *screws*, *bolts*, *sleeves*, *carburettor jets*, indeed any *component* required in Mechanical Engineering.

Since many machines and most machine tools are operated electrically, the terminology merges with that of Electrical Engineering (Chapters 2/7). Metal workers, machine technologists and indeed all mechanical engineers need to be familiar with *material properties*, particularly those of *metals*, such as *melting point*, *fatigue strength*, *shear stress*, and require a number of practical skills, including *brazing*, *welding*, *forging*, *joining*, using *hand* as well as *machine tools*.

Figure 9A lists nouns describing the properties of engineering materials and Fig.9B contains some verbs summarising the various operations involved in metal-working. The names of machine tools often consist of simple compounds involving these terms, such as *broaching/slotting/grinding/reaming machine*, which are abbreviated to *broacher, slotter, grinder, reamer* in the layman language. But there are exceptions: *to turn* (Ge. *drehen)*; *lathe* (Drehmaschine). The term *machining* covers all cutting operations using machine tools. Fig.9C lists the main metal-working tools and their respective *components*. Interested readers are recommended to consult standard textbooks which define the terms of Fig.9A-B, clarify the distinctions and illustrate the tools of Fig.9C.

Mechanical engineers are employed to install engines and other machinery for various applications, for instance in ships, submarines, cranes, elevators, escalators, factories and factory workshops. Much of the terminology of Automobile Engineering (Chapter 8) is applicable for other engines and gear systems, and terms from Chapter 1 - *force, energy, power, work, tension, stress, torsion, momentum*, appear repeatedly.

Usually in British technical English the term *motor* implies *electric motor*, and *engine* covers everything else - *diesel engine, steam engine, rocket engine*, etc. But occasional exceptions exist, usually introduced via American English, such as *motorboat*. *Rotary engines* fitted with *vanes* turned by *fluid pressure* (steam, etc) are referred to as *turbines* and are particularly important in *power stations*. The terms *machine* and *machinery* are applicable to *gear systems, lever arrangements, interlinked rotating shafts*, and *electric drive systems* (motors), but often exclude engines and turbines.

9.2 Civil/Construction Engineering

Civil engineers receive a similar basic education to that of mechanical engineers, and are responsible for the erection and installation of buildings, bridges, flyovers, harbours, roads and other permanent constructions. Construction Engineering covers much the same field as Civil Engineering and is simply a more general term employed when the project concerned is not a *civil* one (one for direct public use), such as the *radioactivity containments* of *fast breeders* at *nuclear power stations*. *Construction engineering* is the preferred term in American English in general.

Whereas civil engineers require a grounding in mechanical engineering in order to operate cranes, winches, bulldozers and other heavy machinery, mechanical engineers need some knowledge of construction engineering in order to design *support systems* for engines, turbines and light machinery. Some basic conceptual distinctions concerning bridges and other *support structures* are discussed in Chapter 1, particularly *stress/strain*, *tie/strut*, *tension/compression*, *moment/torque*.

Forces applied to bridges, winches, crane jibs, etc cause *stresses* in the materials concerned. Different materials *fracture* or *rupture* in different ways, and different *components* of stress are considered, such as: *bending/shear/-torsional/compressive/tensile* stresses, each of which give rise to the appropriate *strain* (section 1.4.4). The study of *material strengths* (stress/strain relations) is the job of a *metallurgist* (section 9.4) and involves *Materials Science* (Chapter 3) as well as a sound knowledge of *Physics* (Chapter 1).

9.3 Nautical, Aeronautical Engineering

The *engines* of ships, submarines, aircraft and rockets are designed by mechanical engineers. *Control systems* are the domain of electrical and electronics experts, whereas *support systems* for assembling large ships, heavy planes and multi-stage space rockets are the responsibility of construction engineers. Specialist *nautical* and *aeronautical* engineers deal primarily with the design of *hydrodynamic hulls* (ships) and *aerodynamic air-frames* (aircraft). *Aerodynamic design* is also important in the automobile industry and certain other areas, such as *railways* (Am. *railroad*). The global concept covering both *aero-* and *hydrodynamic design* is *streamlining*.

Nautical and aeronautical engineers design sea-, air- or spacecraft which move as efficiently as possible in the respective *medium*. *Streamlined craft* disturb the *streams* of air or water as little as possible and consequently create the minimum *turbulence* and minimum air/water resistance, so-called *drag*. The design of such craft requires extensive *computer simulation* and employs complex *mathematical models*. Only in the case of Space Technology, equipment designed for use outside the earth's atmosphere, does *streamlining* lose its relevance, giving way to other crucial engineering factors: effects of *temperature extremes*, *high velocities*, *ionised particles*, etc.

All *engines* of planes, helicopters, rockets, submarines and ships develop *thrust* (Ge. *Schubkraft*), namely they expel accelerated particles which *propel* the *craft* forwards. The engines (or turbines) themselves and the type of *fuel* (steam, diesel, nuclear, chemical) differ greatly but the method of *propulsion* is the same in each case, namely Newton's Principle of *Action/Reaction*. The *force* with which particles are expelled creates an equal and opposite force (reaction) which propels the craft forwards. It functions even in a *vacuum* (outer space). In view of the similarities, it will not surprise the reader to learn that certain *sea-going vessels*, such as hovercraft, are designed and operated by *aeronautical* rather than *nautical* engineers.

Although large fields, Nautical and Aeronautical Engineering currently provide little work for free-lance translators. Apart from "consumer" areas such as *sailing*, *gliding*, *parachuting*, most projects are military ones.

9.4 Metallurgy

Metallurgy concerns the science and technology of metals in general, where the term *metal* includes *alloys* - *mixtures* of metals and other substances (eg *carbon*), to modify the basic properties. Machine technologists employ a variety of metals, including *copper*, *zinc* and *aluminium* and various alloys, such as *brass* (copper and zinc), but the main metals used in mechanical, civil and other engineering areas discussed above are *iron* and *steel*.

The difference in practice between *iron* and *steel* is usually defined by the *carbon* content since both terms imply *alloys* containing the *chemical element iron*. However, such distinctions are not always reflected in the terminology. The term *non-alloyed steel* implies that only *carbon* is added, whereas *alloyed steel* (syn. *alloy steel*) implies that constituents such as *aluminium*, *chromium*, *cobalt*, *copper*, *manganese*, *nickel*, *sulphur*, *titanium*, *tungsten*, are present.

Mechanical engineers need a basic knowledge of metallurgy, but as a science the latter is closer to Chemical Engineering, the field of Chapter 10, than Mechanics.

Figure 9A: Material Properties

abrasion resistance	Verschleißfestigkeit
bending strength	Biegefestigkeit
brittleness	Brüchigkeit
compressive strength	Druckfestigkeit
cracking resistance	Rißbeständigkeit
deformability	Verformbarkeit
ductility	Zähigkeit
fatigue strength	Dauerfestigkeit
flexibility	Biegsamkeit
forgeability	Schmiedbarkeit
grindability	Schleiffähigkeit
impact resistance	Schlagfestigkeit
imperviousness	Undurchläßigkeit
lubricity	Schmierfähigkeit
machinability	Zerspanbarkeit
opaqueness	Undurchsichtigkeit
plasticity	Bildsamkeit
rigidity	Steifigkeit
shear strength	Scherfestigkeit
stability	Festigkeit
susceptibility to ageing	Alterungsbeständigkeit
tensile strength	Zugfestigkeit
torsional strength	Verdrehfestigkeit
translucency	Lichtdurchläßigkeit
workability	Bearbeitbarkeit

Figure 9B: Metal-Working Verbs

anneal	glühen	plane	hobeln
bond	kleben	punch	lochen
bore	bohren	rivet	nieten
braze	hartlöten	roll	walzen
broach	räumen	seam	falzen
cast	gießen	slot	stoßen
clamp	einspannen	square	besäumen
cut	zerspanen	turn	drehen
drill	bohren	weld	schweißen
finish	schlichten		
forge	schmieden		
grind	schleifen		
groove	nuten		
machine	zerspanen		
mill	fräsen		

Figure 9C: Tools

1	machine tool	Werkzeugmaschine
11g	drilling machine	Bohrmaschine
111p	twist drill	Spiralbohrer
12g	lathe	Drehmaschine
121p	chuck	Drehfutter
122p	carriage	Schlitten
123p	tailstock	Reitstock
13g	grinding machine	Schleifmaschine
131p	grind wheel	Schleifscheibe
14g	planing machine	Hobelmaschine
15g	milling machine	Fräsmaschine
151g	gear miller	Zahnradfräsmaschine
152g	cam miller	Nockenfräsmaschine
153g	thread miller	Gewindefräsmaschine

16g	slotting machine	Stoßmaschine
161p	ram	Stößel
162p	ram guide	Stößelführung
163p	cutting tool	Schneidmeißel
17a	workpiece	Werkstück
2	hand tool	Handwerkzeug
21	vice (Am vise)	Schraubstock
22	spanner (Am wrench)	Schraubenschlüssel
221	open-jaw spanner	Maulschlüssel
222	ring spanner	Ringschlüssel
223	socket wrench	Steckschlüssel
224	allen key	Stiftschlüssel
225	monkey wrench	verstellbarer Schlüssel
23	pliers	Zange
231	flat-nose pliers	Flachzange
232	long-nose pliers	Spitzzange
233	round-nose pliers	Rundzange
234	universal pliers	Kombizange
235	pincers	Kneifzange
3	callipers (Am calipers)	Tasterlehre
31	inside callipers	Innentaster
32	outside callipers	Außentaster
33	slide callipers	Schiebelehre
34	micrometer callipers	Bügelmeßschraube
35	dividers	Spitzzirkel

Figure 9D: Screws/Bolts

1g	screw	Schraube
11g	countersunk screw	Senkschraube
12g	cheesehead screw	Zylinderschraube
13g	slotted-head screw	Schlitzschraube
14g	cross-head screw	Kreuzschlitzschraube
15p	screw thread	Gewinde
2g	bolt	Schraube
21a	nut	Mutter
211g	hexagonal nut	Sechskantmutter
212g	square nut	Vierkantmutter
213g	lock nut	Gegenmutter
214g	wing nut	Flügelmutter
22a	(plain) washer	Unterlegscheibe
23a	spring washer	Federring
24a	split pin/(Am) cotter pin	Splint

Chapter Ten

CHEMICAL ENGINEERING

Much of the basic vocabulary of Chemical Engineering appears in Chapter 3, including the common *elements* (Fig.3B) and the constituents and parameters characterising *atoms*. A list of everyday *compounds* together with their respective *chemical formulas* appears in Fig.10A. This Chapter draws attention to certain basic concepts which characterise *chemical substances* and their uses in other engineering fields.

Although new *materials* are devised every year, especially in the *polymer* and *plastics* industries, the basic terminology of chemical engineering remained reasonably constant until just recently. Suddenly, new names are appearing for *chemicals* which were almost everyday terms, for instance *ethanoic acid* (acetic acid), *tri-oxygen* (ozone), *sodium hydrogensulphate* (sodium bisulphate). The new names correspond better to the respective *chemical compositions* than the old ones and if the new terminology settles down in the English-speaking world, the German terms will probably be adjusted accordingly. At the moment this is a difficult area for many translators who are not likely to realise, for example, that *tartaric acid* and *2,3-dihydroxybutanediodic acid* correspond to the same chemical.

Metal, non-metal, acid, alkali, base, salt, agent, solvent, solution, catalyst, are everyday terms relating to *chemical substances*. The *technical* meanings of these terms are much more limited than their *general* significances, and are best understood by reading an elementary textbook of Applied Chemistry, but the following subsections should clarify the main distinctions.

10.1 Metal, Non-Metal

The distinction between *metallic* and *non-metallic elements*, so-called *metals* and *non-metals*, is made by drawing a diagonal line through the *Periodic Table* (Fig.3A) at a certain place. The chemical definition of a *metal* is "an *element* in which the number of *valence electrons* is less than or equal to the *period number*", the remaining elements being *non-metals*. All elements of the Periodic Table above or on the line joining the elements *helium* to *astatine (He, B, Si, As, Te, As*), and *hydrogen* (*H*), are classed by the chemist as *non-metals*. The rest are *metals*.

Thus *carbon, phosphorus, sulphur, chlorine, oxygen and nitrogen* are regarded as non-metals, whereas *aluminium, germanium, cadmium, antimony, mercury* and indeed the overall majority of elements are termed metals. Those elements of *valency zero*, namely *neon, argon, krypton,* etc constitute a third class, known as *inert elements* or sometimes *noble gases* (Ge *Edelgase*) because of their reluctance to participate in any form of chemical reaction. Molecules of inert elements consist of single atoms and remain, usually as gases, unchanged throughout time, never forming chemical compounds with any other element.

10.2 Solid, Liquid, Gas

The three states of matter *gas, liquid, solid* are differentiated according to whether the molecules of the substance are able to move in three dimensions, two dimensions or not at all. The terms are used by chemists quite strictly, and lead to certain surprises. For instance *glass* is not a solid substance but a highly viscous liquid. As far as *elements* are concerned, most metals are solid at normal room temperature, whereas non-metals may exist in any of the three states. Some solids have a tendency to form *crystals*, particularly *carbon* (diamond), *silicon* and *germanium*.

The term *fluid* is occasionally used to cover both *liquids* and *gases*, especially in reference to *physical* properties: pressure, temperature, etc. In *chemical* contexts, terms such as *emulsion, colloid, gel* differentiate certain liquids, and there is a distinction between *vapour* and *gas*. Substances normally in the liquid state which are induced to form suspensions of tiny particles in air or other gas mixtures are termed *vapours*. The air we breathe is a mixture of *gases* (oxygen, nitrogen, carbon dioxide, etc) together with *water vapour*. An *emulsion* is a fine dispersion of one liquid inside another, such as milk (*oil in water*), paint or medicine. Some emulsions are *colloids*, rather sticky (viscous) substances. Margarine and butter are colloidal emulsions of *water in oil*. Colloidal substances which behave rather like jelly are termed *gels*, an example being *gelatin*, used both in jam-making and in photography.

In chemical processes where one substance, usually solid, is dissolved in a liquid the terms *solute, solvent, solution* are employed. An example is sodium chloride (*solute*) dissolved in water (*solvent*) which results in salt water or *brine* (*solution*). Metals dissolve in *acids* and liberate *hydrogen*. Acids mixed with *alkalis* lead to *salt solutions*. Discussion follows.

10.3 Acid, Alkali, Base, Salt

The chemical definition of *acid* is "a *solution* of a *compound* which contains *hydrogen ions* as the only *positive* ions". Some acids have simple chemical *formulas* such as HCl, HNO_3 and HPO_4, *hydrochloric, nitric, phosphoric acid*. Others, such as *ethanoic acid* (vinegar) CH_3COOH or *tartaric acid* $HOOCCH(OH)CH(OH)COOH$, have a more complex molecular structure. A *base* is defined as a substance which reacts with an *acid* to give a *salt* and *water*. Many bases are chemical compounds of a metal (*Na, Ca, Cu*, etc) together with the combination of oxygen and hydrogen termed *hydroxide* (*OH*), for example *sodium, calcium* or *copper hydroxide*. *Salts* are also obtained by allowing *metals* to react with *acids*. There are *sodium, potassium, magnesium* and many other *salts*, including *common salt NaCl*. *Alkalis* are *bases* which are *soluble* in water.

Acidity has two meanings, one a theoretical concept classifying molecular structure, the other a practical everyday significance. It is contrasted on the one hand with *basicity*, and on the other with *alkalinity*.

The *acidity* of a *base* is the *valency* of the *metal* in the *base*. Thus the acidity of *sodium hydroxide* (NaOH) is 1. The *basicity* of an *acid* corresponds to the number of *hydrogen atoms* in one *molecule* which can be replaced by *metal atoms*. Hence, the basicity of *sulphuric acid* (H_2SO_4) is 2. *Alkalinity* is a practical concept referring to the *pH-scale*, a scale of acidic or alkaline concentrations from *0-14*. Strong acids have *pH-values* approaching zero, strong alkalis approaching 14 and pure water has the value 7. *Acidity* (second meaning) is used in connection with solutions of pH-value below 7, *alkalinity* above. These terms are important in many fields of chemical technology, such as *batteries* or *electroplating*, and have recently entered everyday English in the context of *acid rainfall*.

10.4 Oxidation, Reduction, Catalysis

When copper is heated in air it turns black. It combines with oxygen to form copper oxide. The *oxidising agent* is oxygen itself. Copper is said to be the *reducing agent*. A similar reaction occurs with copper and chlorine, where chlorine is the oxidising agent. *Oxidation* has nothing to do with oxygen in this sense, but concerns the loss or acquisition of electrons. In both cases copper is responsible for *reduction*: copper atoms lose an electron to the oxidising agent and become negative ions, *cations*. The oxidising agent gains an electron and becomes positively ionised, resulting in *anions*. The terms *oxidation* and *reduction* also apply to reactions involving metals and acids, such as iron and hydrochloric acid, *HCl*. In such reactions the reducing agent is generally the *metal*, the oxidising agent (chlorine in HCl) a *non-metal*.

In a chemical reaction, those substances inducing the reaction itself are termed *reagents*, whereas those present simply to speed up the process and which do not themselves undergo any change are termed *catalysts*. The chemical process for the manufacture of *ammonia* employs iron as a catalyst. Substances which slow down a chemical reaction are termed *inhibitors*.

10.5 Isomer, Monomer, Polymer

Organic chemistry concerns *carbon compounds* (the substance of *living matter*) which occur abundantly in nature and technology alike. One class of *organic compound* is that of the *alkanes*: *methane* (CH_4), *ethane* (C_2H_6), *propane* (C_3H_8), *octane* (C_8H_{18}) and others. These compounds exhibit *isomerism*, which means that different arrangements of atoms give rise to different *molecular structures* in substances with the same *chemical formula*. The differences are best understood by observing geometric *models* of the molecules concerned. Texts often contain *planar representations* - equivalent models indicating the relative positions of the various atoms in two as opposed to three dimensions.

Another important area of organic chemistry is *polymerisation*. Just as large *silicon monocrystals* (Chapter 5) are *grown* for the Electronics industry, so it is possible to produce giant molecules - *macromolecules*, from the alkanes. A good example is *polythene* (originally *polyethene*). Such materials are termed *polymers*, where a *mer* or rather *monomer* corresponds to the smallest constituent (eg CH_2). These materials form the basis of the *Plastics* industry. *Plastics* and *synthetic rubbers* currently account for half the world production of organic chemicals. *Plastics* are broadly divided into *thermoplastics* and *thermosetting plastics*. Thermoplastics soften on gentle heating but harden again; their uses include pipes, bottles and bowls. Thermosetting plastics become progressively harder on heating; an example is *bakelite* which is used in *light switches* and other *electrical fittings*.

10.6 Chemical Industries

In many countries, such as Germany or the USA, the *chemical industry* is one of the biggest. It consists, however, not of one *industry*, but many different *engineering* and other *branches* responsible for such things as: *synthetic fibres*, *synthetic materials* (plastics), *pharmaceuticals*, *fertilisers*, *pesticides*, and many small but highly profitable specialised industries including *artificial leather*, *synthetic rubber*, *resins* and *silicones* (lubricants composed of *molecular chains* of alternate *silicon* and *oxygen* atoms). Battery manufacture or *electrolysis* - the *coating* of *sheet metal* with *tin*, *copper*, *zinc* and other metals less sensitive to rusting by means of an electric current, are the industries which usually spring to mind, however, when the term *chemical engineering* is mentioned. This is mainly because of the vast quantities of dangerous acids involved, the residues of which are simply *dumped*, sooner or later, somewhere in the environment (oceans, rivers, etc). This and other problems, including the dumping of pharmaceutical wastes, in "third world" countries, has given the Chemical Industry a bad name in recent years.

Whereas governments impose strict controls on nuclear materials, they are notoriously lax when it comes to supervising the *dumping* of *chemical wastes*. Just as chronic air pollution and murderous smogs led to higher and higher factory chimneys, so the pollution of soil, ground water, rivers and estuaries now leads to *chemical dumping* farther and farther out to sea. The gradual destruction of the complete biosphere of our planet by chemical pollutants means that much of current technical literature is concerned with minimising the dangers, particularly where the substances concerned are banned in many countries. Apart from a knowledge of basic Chemistry, which can be acquired from textbooks relatively quickly, translators working in this area need some grasp of the vocabulary of Soil Sciences, Forestry, Biochemistry, Oceanography and above all an awareness of the current political scene. At the moment, most industrial literature on waste disposal concerns "legal dumping", but within two decades the balance may swing towards attempts at *reprocessing* dangerous chemical wastes to obtain substances which are truly non-detrimental to the environment or public health. The *waste disposal industry* may then become the most profitable chemical industry of all.

Figure 10A: Chemical Substances

CaC_2	calcium carbide	Calciumcarbid
NaCl	sodium chloride	Natriumchlorid
NaF	sodium fluoride	Natriumfluorid
CO_2	carbon dioxide	Kohlendioxid
SO_2	sulphur dioxide	Schwefeldioxid
NaOH	sodium hydroxide	Natriumhydroxid
NaOH	caustic soda	Natronlauge
HNO_2	nitrous acid	saltpetrige Säure
H_2SO_3	sulphurous acid	schweflige Säure
H_2SO_4	sulphuric acid	Schwefelsäure
H_2CO_3	carbonic acid	Kohlensäure
HNO_3	nitric acid	Saltpetersäure
H_3PO_4	phosphoric acid	Phosphorsäure
HCl	hydrochloric acid	Salzsäure
H_2S	hydrogen sulphide	Schwefelwasserstoff
HCl	hydrogen chloride	Chlorwasserstoff
HF	hydrogen fluoride	Fluorwasserstoff
O_2	oxygen	Sauerstoff
O_3	ozone	Ozon
O_2	di-oxygen	Disauerstoff
O_3	tri-oxygen	Trisauerstoff
NH_3	ammonia	Ammoniak
CH_4	methane	Methan
C_3H8	propane	Propan
K_2SO_4	potassium sulphate	Kaliumsulfat
$Ca_3(PO_4)_2$	calcium phosphate	Calciumphosphat
$CaCO_3$	calcium carbonate	Kalziumcarbonat
$NaClO_3$	sodium chlorate	Natriumchlorat
KNO_3	potassium nitrate	Kaliumnitrat
Na_2SO_3	sodium sulphite	Natriumsulfit
KNO_2	potassium nitrite	Kaliumnitrit

Figure 10B: Chemical-Laboratory Terms

pH	pH-Wert
chemical formula	chemische Formel
acid	Säure
organic compound	organische Verbindung
inorganic compound	anorganische Verbindung
chemical compound	chemische Verbindung
hydrous substance	wasserhaltige Substanz
non-metallic oxide	Nichtmetalloxid
mixture	Gemenge
base	Base
electrolyte	Elektrolyt
alkali	Lauge
colloidal sol	Sol
colloidal sol	kolloide Lösung
chemical equation	chemische Gleichung
chemical reaction	chemische Reaktion
saturated solution	gesättigte Lösung
non-saturated solution	ungesättigte Lösung
super-saturated solution	übersättigte Lösung
aqueous solution	wäßrige Lösung
water vapour	Wasserdampf
catalysis	Katalyse
hydrolysis	Hydrolyse
electrolysis	Elektrolyse
litmus	Lackmus
salt	Salz
reducing agent	Reduktionsmittel
oxidising agent	Oxidationsmittel
solvent	Lösungsmittel
boiling point	Siedepunkt
melting point	Schmelzpunkt
catalyst	Katalysator
solubility	Löslichkeit

Chapter Eleven

COMPUTER ENGINEERING

Just as every professional person can be expected to have owned a motor car at some time in his life so most translators are likely to have some experience of computers. The younger generation of linguists have plenty of opportunity at home, school or university to acquaint themselves with *PC's*, *VDU's*, *floppy drives*, *keyboards* and *diskettes* and other aspects of *computer hardware*. Hence this area requires little introduction and is only touched upon for the sake of completeness.

Some of the older generation of translators still stubbornly refuse to have anything to do with *computational methods* and cling to their out-dated typewriters and card-indexes but in so doing their prices become unrealistic. As free-lance translators these people are members of a dying race. This Chapter briefly outlines the field of *Computer Engineering* with regard to technical translation, and leads to Chapter 12, which demonstrates the usage of lexica in this book and Volume 2.

11.1 Computer Systems

Generally speaking, Computer Engineering is not a difficult area for translation despite the large vocabulary which, together with that of associated areas such as Semiconductors, Electronics and Electrical Engineering, covers hundreds of thousands of specialised concepts. Probably, no other technical field has ever grown at such a phenomenal rate, but thanks to continual efforts from within the field to standardise its terminology, it can safely be assumed that each term corresponds to the same concept throughout the English-speaking world. Hence, unlike Automobile Technology for instance, differences between British and American hardly exist. Even the spelling conforms: *disk, diskette, program*, etc. New terms are often accepted into German without modification - *Monitor, Operator, Debugging*, and the German *layman language* abounds with jargon, such as *ge-saved, booten, Directory, User, Printer*, with appropriate German-sounding pronunciations.

Translators are not likely to make too many terminological errors in this field, except where dictionary entries are misleading because the terms concerned either refer to obsolete equipment, or have acquired a new significance. Complete terminologies from the seventies, in areas such as *punch-card hoppers, magnetic core store, magnetic cards, magnetic tape decks, paper-tape readers*, are only of academic interest and could now be removed from "pocket" dictionaries, whereas modern terms are often absent. Certainly, in no other field are the short-comings of the conventional printed dictionary more evident. Consequently computer manufacturers themselves have continually maintained *terminological data banks* for all aspects of *computer systems*, (strictly *data-processing systems*), since the seventies and currently offer the most accurate, up-to-date technical dictionaries on the market.

Figures 11A-F offer only a minute subset of the enormous terminology of data-processing systems, and is intended not so much for translation purposes as for rapid communication between German and English-speaking computer enthusiasts. English computer users may flounder when working for the first time at a German keyboard, where keys such as *DEL, INS, Home, Ctrl, Break*, are replaced by *Einfg, Entf, Pos1, Strg, Abbr*. A glance at Fig.11D will assist. German speakers seated at American keyboards are less troubled by this particular problem, more so by English text-processing software. They too will profit from the *keyset* and *text-formatting* terms of Fig.11C/F.

There are two aspects of *data-processing systems* - *hardware* and *software*, and several types of system including *PC's, mainframes, processors* and *industrial robots*. These are discussed in the following sections.

11.2 Hardware

Hardware engineers are responsible for designing the various physical devices which constitute a computer system: apart from items such as the *diskette drive*, *monitor* and *keyboard*, this mainly involves complex *switching circuitry*, the *switching IC's*, *modules*, etc, responsible for carrying out *binary instructions*. The term *hardware* is contrasted with *software*, namely the *programming* and *package facilities* - sequences of *instructions* written in formal *programming languages*, which are convertible into *binary instructions*.

Much of the basic vocabulary of Computer Hardware is that of Semiconductor Electronics (Chapters 5-6), an area responsible for both *logic* and *memory modules*. *Logic circuits* are composed of various *gates* - AND, OR, NAND, NOR, NOT (negation). These *logic gates* execute simple *logic operations* on the *binary data* of *memory cells*, similar to those involved in the formal solution of standard philosophical arguments, where logic operations are performed on simple semantic propositions. The *binary* output *states* (ON/OFF, O/1) are *functions* of the *input states* and equivalent to the philosopher's *truth table* entries (TRUE/FALSE).

Logic gates consist of *electronic switching circuits*, so-called *astable multivibrators*, whose output corresponds to one of two stable states. The layman term for this and other types of *multivibrator*, namely *flipflop* has also made its way into German. *Flipflops* are combined to form *binary counters*, *decoders*, *registers* and *adders*, which are required to carry out the fundamental *logic* and *arithmetic* operations involved in *electronic data-processing* (Ge. *EDV*).

Memory Units consist of *cells* divided into *bytes* and ultimately *bits*. The *bit* (derived from *binary digit*) is the smallest fragment of binary information and corresponds to one of two states (O/1, ON/OFF, TRUE/FALSE, etc). It can be regarded as a single *switch*. A *byte* consists of eight adjacent *bits*, and since the latter can each have two states, one byte provides 256 different combinations (2 to the power 8). The series of adjacent bytes constituting one *memory cell* is termed the *machine word*, or simply *word*. Computer systems or, in specialist jargon, *machines* are distinguished according to the size of their *words*; there are machines with 8-, 16- or 32-byte words and small *pocket calculators* with 4-byte words. The memory units themselves may consist of *flipflops* similar to those of *logic gates* but more sophisticated devices are also employed, often involving magnetic techniques.

The terms *store* and *memory* (Ge. Speicher) are not synonymous in this field. *Store* is employed in the context of *permanent storage*, storage on a *medium* outside the *CPU* (central processing unit) such as *diskette*, *disk* or in the case of older systems - *magnetic* or *paper tape*. *Memory* implies storage within the system itself, information which is immediately lost when the computer is switched off or the batteries are removed. Hence the terms: *working memory*, *ROM* (read-only memory), *RAM* (random-access memory).

Early flipflops were assembled from *discrete devices* (Chapter 6) and employed first *relays* and later *transistors* as the main *switching devices*. Subsequently *logic gates* were manufactured as *IC's*, followed by *counters*, *decoders*, *registers* and *memory units* in *modular form*. Complete *processors* and *memory units* are now available as *IC-modules*, such as the *CPU* and *ROM* units of the common *PC*. The gradual evolution of flipflops and other devices led to the various different *computer generations* (usually acknowledged as five or six). So far, advances have been dependent on *hardware* (electronics, etc) but the next generation of computers will probably emerge from *software* fields, such as *artificial intelligence*.

11.3 Computer, Processor, Calculator

Computer is a rather loosely defined term covering all *data-processing systems* from *mainframes* to *PC's*. *Mainframes* are large computer systems in universities and industrial research laboratories, which are accessed from *terminals* by many *users* simultaneously. Next on the scale are the individual *mini-* and *micro-computers* used by engineers and architects for designing machines, bridges or planes, which employ *CAD* systems (computer-aided design), and finally there are *office* and *personal computers* (PC's), which have now reached the average household (including mine).

A *processor* (syn. *data processor*) is a computational system which runs on a *fixed program*. The *instructions* cannot be changed by the user, although sometimes the fixed program itself can be substituted. *Processors* are used in *production lines* of various industries, including the Electronics industry itself. *Industrial robots*, found in car plants, etc, are *processors* guided by *optical sensors*. *Calculators* are simple *pocket* or *desktop* devices for carrying out arithmetic or other mathematical calculations. They are also *processors* but, unlike *robots*, the *data* is provided via the *keyset* and not by *sensors*.

The term *data-processing system* (Ge. *DVA*) covers computers and processors and includes both hardware and software. Nevertheless, it is too clumsy and too similar to *data processor* for repeated use, and generally avoided in English in favour of *computer system*, *computer* or *processor* as the case may be.

11.4 Mainframe, PC

In the case of *mainframe computer systems* many different users have to communicate with the *CPU* via *terminals* and receive their results at a *printer*, (graph) *plotter*, or from a certain *store unit*, *disk*, etc. These various devices are termed *peripherals*, (syn. *peripheral device)*; there are *input*, *output* and *storage peripherals*. Each *user* submits his instructions in the form of a *job*, where *job* is defined as *user program* plus *data*. The jobs are *executed* in order of submission or according to a given *priority sequence* and the results returned to the appropriate *peripheral device*, often the *printer*. The respective user (or his department) is then *charged* according to the amount of *processing time* (syn. *computer time*) required. Hence the expressions: *job queue*, *run-time*, *job-time*. For *PC's* much of the above vocabulary is irrelevant.

11.5 Software

The cost of early computers was determined almost exclusively by their hardware. The *software*, namely the programming facilities provided, was not very extensive and *users* had to know almost as much about the intricate working of the machine as the manufacturers themselves. The situation began to change with the introduction of *user programming languages*, such as *Fortran* and *Algol*, in the late fifties and early sixties. These *programming languages* enabled the user to *code* his instructions for the machine using mnemonic symbols, so-called *delimiters*, such as READ, WRITE, GOTO, END. *User programs* were mainly mathematical and employed *variables* (x,y,p,q,s2,T6, etc) corresponding to *addresses* in the *working memory* where *numerical data* were stored for the duration of the program. The user program was then automatically translated into the *machine language* at *run time*, a process known as *compilation*. The situation is much the same today but the programming languages have been extended to include *lexical* as well as *numerical data-processing*, and other facilities such as *sound* or *graphics* have been added. Many new languages have evolved, such as the frequent PC languages *Basic* and *Turbo-Pascal*.

The cost situation is now completely reversed. *Software* constitutes the main expense of any computer buyer, and is available in the form not only of *programming languages* but also *packages*. The latter are fixed, *compiled programs* for particular applications, including *text processing, letter writing, book-keeping*, and various *computer games* using *mouse* and *joystick*. Packages have many advantages but one disadvantage is that the *data* which has been *input* is difficult or impossible to access without the package program. This is often a problem with *word processors*, that is to say *package programs* for using a PC like a sophisticated typewriter.

This book was written, and the glossaries and dictionaries were compiled on a small domestic computer (512 K) in the author's own home. All programs for processing the text and dictionary data were in the language *Turbo-Pascal*. Using a somewhat antiquated Amstrad PC1512 and a Turbo-Pascal 3.0 compiler the author's first job was to acquire the necessary programming skills for obtaining the Global Index and the various glossaries of Volume 2. The *text editor* and *print program* were also written from first principles for ease of access in cross-referencing the different sections. Some of this work would now be redundant, as PC's, sixty times as powerful (*30 megabyte*), are available which can handle the elaborate *text-processing* and *data-base* software, once restricted to *mainframe systems*.

However, since the system used was *MS-DOS* (Microsoft Diskette Operating System) and the data was maintained in *ASCII* (American Standard Code of Information Interchange) characters it was not difficult to reprocess the final book, with improved hardware and software facilities, using the standard text editor *WORD PERFECT 5.0*. The result was submitted in *camera-ready* form, complete with *headings, page numbers, type fonts*, etc, and is what you see now.

Figure 11A: Computer System

mainframe

1p	hardware	Hardware
11p	CPU	CPU; Zentraleinheit
111p	working memory	Arbeitsspeicher
112p	control unit	Steuerwerk
113p	arithmetic unit	Rechenwerk
12p	peripheral	Peripheriegerät
121g	input peripheral	Eingabegerät
122g	output peripheral	Ausgabegerät
123g	storage peripheral	Speichergerät

PC

2	PC system	PC-Anlage
21p	system unit	Systemeinheit
211a	disk drive	Laufwerk
212a	hard disk	Festplatte
213a	monitor pedestal	Monitorsockel
214a	interface	Schnittstelle
215p	CPU	CPU (Zentraleinheit)
2151p	RAM	RAM (Schreib-/Leserspeicher)
2152p	ROM	ROM (Festwertspeicher)
22p	VDU	Bildschirmeinheit
221p	monitor	Monitor

222p	monitor screen	Bildschirm; Monitor
23p	keyboard	Tastatur
24p	mouse	Maus
25p	joystick	Joystick
26p	printer	Drucker

ROM = read-only memory
RAM = random-access memory
CPU = central processing unit
VDU = visual display unit

Figure 11B: Keyboard

1	keyboard	Tastatur
11p	text keys	Schreibfeld
12p	control keys	Steuerfeld
13p	cursor keys	Cursorblock
131p	cursor shift	Cursorbewegungstaste
1311g	right shift	Cursor nach rechts
1312g	left shift	Cursor nach links
1313g	upshift	Cursor nach oben
1314g	downshift	Cursor nach unten
1315g	scroll up (PgUp)	Seite nach oben
1316g	scroll down (PgDn)	Seite nach unten
1317g	home (Home)	Textanfang (Pos1)
1318g	end (End)	Textende (Ende)

PgUp, PgDn, Home, End, Pos1, Ende are the respective keys on an IBM PC.

Figure 11C: Keyset

1	key	Taste
11a	character	Zeichen
111g	alphanumeric	alphanumerisches Zeichen
1111g	letter	Buchstabe
1112g	numeral	Zahl
1113g	dash	Strich
11131g	hyphen	Bindestrich
11132g	slash	Trennstrich
111321g	backslash	linksschräger Trennstrich
112g	space	Leerzeichen
113g	punctuation char.	Satzzeichen
114g	control character	Steuerzeichen
115a	character set	Zeichensatz
12g	space key	Leertaste
13g	control key	Steuertaste
14g	function key	Funktionstaste

Figure 11D: Control Keys

alternative (Alt)	Alternative (Alt)
break (Break)	Abbruch (Abbr)
case shift	Umschalten
control (Ctrl)	Steuerung (Strg)
delete (Del)	Entfernen (Entf)
enter (Enter)	Eingabe
insert (Ins)	Einfügung (Einfg)
escape (Esc)	Eingabe Löschen (Esc)
print screen (PrtSc)	Bildschirm Drucken (Druck)

Figure 11E: File Handling

data file	Datei
data record	Datensatz
file directory	Dateiverzeichnis
load	laden
save	sichern
delete	löschen
print	drucken

Figure 11F: Text Format

aligned left	linksbündig
aligned right	rechtsbündig
bold face	Fettdruck
column	Spalte
footnote	Fußnote
heading	Kopfzeile
italics	Kursivschrift
line	Zeile
lowered	tiefgestellt
margin	Heftrand
raised	hochgestellt
underlined	unterstrichen

Chapter Twelve

LEXICOGRAPHY

This Chapter, unlike the previous ones, is not concerned with describing the vocabulary of any particular technical field, but simply provides general guidelines for accessing the terminology of the other Chapters in the most effective manner. It is divided into four sections discussing, in turn, each of the four dictionary presentations offered in this book - *hierarchic*, *reverse-alphabetic*, *collocational* and *alphabetic*. It is mainly concerned with the Term Lists following each of the preceding chapters, and the Global Index, but also mentions the technical glossaries of Volume 2: the Polyseme Dictionary, the Thesaurus and the Collocation Dictionary. Readers not concerned with German and hence less interested in Volume 2 should concentrate on sections 1 and 4 below.

Chapters 1-11 cover the following areas. The list includes the *Field Codes* in the Dictionaries of Volume 2.

PHYS:	Physics
ELEC:	Electrical Engineering
MATS:	Materials Science
NUCL:	Nuclear Engineering
SEMI:	Semiconductor Engineering
ELNC:	Electronics
AUTO:	Automotive Engineering
MECH:	Mechanical Engineering
CHEM:	Chemical Engineering
DPS:	Computer Engineering (Data Processing Systems)

The Chapters and Dictionaries also touch upon associated fields, such as Mathematics and Constructional Engineering, and many subfields - Braking, Transformers, Televisions, etc. A full list appears at the start of Volume 2. The above Codes appear occasionally in the discussion following.

12.1 Hierarchic Listing

Some of the *Term Lists* following the Chapters are arranged *alphabetically* (Fig.1, 2A), others (Fig.10A-B) appear in *reverse alphabetic order*. But in most cases it has been possible to provide a more *systematic* arrangement, in the form of a bilingual *hierarchy* of concepts. These hierarchic lists provide a summary of the preceding Chapter and contain additional information, as the *hierarchies* provide a kind of "artificial context" which enables *entries* to be "defined" in terms of other entries. Some examples follow, which will illustrate this. In all Term Lists, whether alphabetic, reverse-alphabetic or hierarchic, the convention adopted is "English left, German right".

Fig.4C contains a hierarchic list of *elementary particles* occuring in Nuclear Technology. A translator who knows little about this field can determine semantic relationships among the particles by observing their hierarchic classification codes. Hence, the particle *proton* (12211) is a type of *nucleon* (1221), the latter coming under the category of *baryon* (122). Similarly *neutrons* (12213) are also *nucleons* and therefore *baryons*, but are quite different from *neutrinos* (112), the latter being *leptons* (11).

This is one kind of terminological hierarchy, the so-called *generic hierarchy* which concerns the logical relationship *genus/species* (as in Biology). There are other hierarchic lists which involve the semantic distinction *part/whole*, so called *partitive hierarchies*. Fig.11A contains a list of basic terminology relating to *mainframe hardware* and is a hybrid mixture of the two kinds. The distinction *partitive/generic* is indicated by attaching an *ontological descriptor* (subscripts *p/g*) to the logical (hierarchic) classification code. Hence, in Fig.11A *working memory* (111p) is part of the *CPU* (11p), itself part of the *hardware* (1).

Hierarchic organisation is a technique commonly employed by philosophers, semanticists and, above all, computer scientists working in areas such as Information Retrieval, Automatic Translation and Artificial Intelligence. These people use many different ontological descriptors, but for the simple lexicographical applications here only four were felt to be essential, namely *g*, *p*, *m*, *a* - corresponding to *generic*, *partitive*, *metric* and *associative* relationships.

A *metric relationship* implies that the subordinate concept corresponds to a measurable parameter of the superordinate one. For instance, in the *automobile* terms of Fig.8B: *delivery pressure* (233m) refers to *fuel pump* (23p), *specific gravity* (311m) to *battery acid* (31p), and *electrode gap* (142m) to *spark plug* (14p). The label *associative* is used for relationships not covered by the other three categories, but where there is nevertheless a strong semantic association between the concepts concerned. For example, in Fig.8B: the *hydrometer* (3111a) is used in connection with the *specific gravity* (311m) of *automobile batteries* (3).

Terminological hierarchies help to avoid a lot of repetitive definition in the Chapters themselves and constitute a valuable instructive aid for the reader in helping him to organise the concepts systematically in his own mind. Readers who come across the hierarchic organisation of information here, for the first time, are advised to peruse Term Lists of familiar or relatively straightforward areas such as Automobile Engineering (Fig.8B-E) or Computer Technology (Fig.11A-C), and get aquainted with the system of organisation before studying the book.

The Technical Thesaurus of Volume 2 employs similar hierarchic techniques and several additional ontological descriptors.

12.2 Reverse Listing

Rather than include a simple alphabetic German/English glossary, the so-called Polyseme Dictionary of Volume 2 incorporates *reverse listing*. There are many advantages not shared by the conventional alphabetic approach, since terms *ending* in the same characters appear adjacently, thus revealing polysemes in technical literature.

Consider the following extracts from a simple reverse dictionary. The codes *OPT, MEAS, TOOL* correspond to the areas Optics, Measurement, Tools.

Zerlegung	*AUTO*	disassembly
chemische Zerlegung	*CHEM*	chemical decomposition
elektrolytische Zerlegung	*CHEM*	elektrolytic dissociation
Kräftezerlegung	*PHYS*	resolution of forces
Lichtzerlegung	*OPT*	light dispersion
Balkenwaage	*MEAS*	(pair of) scales
Brückenwaage	*AUTO*	weighbridge
Laufgewichtswaage	*MEAS*	slide scales
Präzisionswaage	*MEAS*	precision scales
Wasserwaage	*TOOL*	spirit level

A student translator looking for the English equivalent of *Zerlegung* immediately realises that the term is translated differently in various compounds from different areas. The exercise of locating *Präzisionswaage* in a reverse dictionary gives the translator confidence in finding the English equivalent of *Waage*, owing to other adjacent compound terms from the same field. It also helps to establish the semantic domains of the various polysemes, and imprints them in his mind for subsequent translation work.

Professional translator's should not make elementary mistakes with simple concepts like *Waage*, but may hesitate in the cases below, most of which are resolved by a glance at the Polyseme Dictionary:

Gehäuse: chamber; boss; housing; casing; case.
Gerät: appliance; device; unit; equipment.
Welle: shaft; spindle; rod; (wave).
Zange: pincers; pinchers; pliers; tongs.

Nor would they obtain an appropriate rendering so quickly for the following terms in specific situations:

Mittel:	agent; solvent; lubricant; coolant; flux.
Gerät:	peripheral; charger; recorder; instrument.
Scheibe:	disc; pulley; screen; wheel.
Zange:	strippers; cutters.

The Polyseme Dictionary fulfils a number of lexicographical functions simultaneously by arranging for entries to occur adjacently which are morphologically similar and exhibit the following properties:

synonymy:	*Kernkräfte/Kernbindungskräfte* - nuclear forces.
	Kernladungszahl/Ordnungszahl - atomic number.
antonymy:	*Sperr-/Durchlaßpolung* - forward/reverse bias.
	Vor-/Leistungsverstärker - pre-/power amplifier.
homonymy:	*Wellenlehre* - caliper gauge; wave mechanics.
	Buchse - socket; bush.
polysemy:	*Platte* - disc; disk; plate; board.
	Gitter - lattice; grid.

Hyponymy, that is to say hierarchic relationships like those of section 12.1, is also evident, but less explicit than in the Term List or Thesaurus arrangement. Fig.10A employs reverse listing, so that the names of different *acids*, *sulphates*, *nitrates*, etc occur adjacently, and illustrates *hyponymy*: compounds ending in *-ate* (sulphate, phosphate, nitrate, etc) have chemical properties distinct from those ending in *-ite* or *-ide*.

Note: The Polyseme Dictionary was originally compiled as an ordinary reverse dictionary, one in which entries are sorted in alphabetical order starting from the *end* of the word, as in Fig.10A. It was then "tidied up" for publication purposes by arranging for terms containing non-polysemous lexemes to appear in conventional alphabetic order, while retaining the basic reverse listing of the remainder. Regretably, standard software is currently unavailable for the compilation of polyseme dictionaries, but the situation could change overnight, as soon as software designers and above all linguists themselves realise their potential.

12.3 Collocation

Most lexicographers are happy to include *technical nouns*, no matter how obscure, in their dictionaries but are unsure how to handle *verbs*, *adjectives*, *prepositions* or *general nouns* such as

Stoff:	substance; material; matter.
Weg:	path; distance; medium; means.
Größe:	magnitude; size; quantity; amount; value.

The great advantage of the Polyseme Dictionary is that the compound terms help to specify the correct translations of the simple terms in a given context. But verbs, adjectives, prepositions and nouns like the above rarely occur in compounds. Hence a different lexicographical technique is required: the Collocation Dictionary.

This Dictionary is comprised of sentences, in both English and German, taken from various German technical texts and listed in alphabetical order of the particular verb, adjective, noun or preposition in the sentence, which is likely to present the main problem for translators, particularly non-native English speakers. It can be regarded as a collection of *collocations* of general words used with a specific interpretation in different technical contexts. Having read Chapters 1-11, the reader should have little difficulty in understanding the subject matter of the sentences. Like the Polyseme Dictionary this is a dictionary to be *read* from end to end and examined closely: translators who do this regularly, particularly non-native speakers will be better equipped to handle a practical translation than those only interested in the rendering of an odd term.

Standard software (data-bank editors) is available for producing collocational dictionaries but needs to be improved, so that entries are accessible in both language directions. The Collocation Dictionary is arranged in order of German, but access to English general vocabulary is possible via a special index, the Collocation Index. Access to *technical* vocabulary in the same Dictionary is possible too, via the Global Index (below). Other collocations of English terminology occur in the Chapters and are accessed via the Global Index in the usual manner.

12.4 Global Access

Unlike the Dictionaries of Volume 2, the Global Index is not interesting to read from end to end. It simply provides rapid access to lexicographical information in Volume 1. The following entries illustrate its usage:

strain: 144 36 91 92 F1
reception: F7B F7C (einb-, vorz-)
RAM: 64 11.2 F11A

The entry for *strain* means that the term is mentioned in Sections 1.4.4, 3.6, 9.1, 9.2 and occurs in Fig.1. Its German equivalent can be obtained directly from Fig.1 or from the bilingual Thesaurus of Volume 2. Similarly *reception* appears in Fig.7B and 7C; *RAM* occurs in Fig.11A and sections 6.4 and 11.2 (Chapter 11 section 2).

The bracketed references concern the Collocation Dictionary of Volume 2. The abbreviations *einb-* and *vorz-* lead to German translations of the term *reception* in the sentences at the entries at *einbauen*, *vorzüglich*. Thus the Global Index enables a further application of the Collocation Dictionary: to demonstrate the *usage* of technical vocabulary in context.

Some translators, particularly those with years of experience of card indexes and alphabetic dictionaries, will read this Chapter briefly and forget it. Others, especially the younger generation of linguists, who are used to coping with complex public library categorisation schemes and have grown up with computers will realise that these two small volumes contain a goldmine of information intricately interlinked via the presentation structure. The glossaries are easy to use but may require a little practice at first. As stated at the outset, good translators must be good detectives.

TERM INDEX

absolute zero	*absoluter Nullpunkt*
ac, AC	*Wechselstrom*
ac current	*Wechselstrom*
ac mains voltage	*Netzspannung*
ac signal	*Wechselstromsignal*
ac voltage	*Wechselspannung*
accelerator	*Gaspedal*
acceptor	*Akzeptor*
acid	*Säure*
acidity	*Säurestärke*
action	*Kraft*
active device	*aktives Bauelement*
adder	*Addierer*
additive	*Zusatzstoff*
address	*Adresse*
adhesive	*Klebstoff*
adjacent atom	*Nachbaratom*
aerial	*Antenne*
AF	*Niederfrequenz, NF*
AF-choke	*NF-Spule*
agent	*Wirkstoff*
air drag	*Luftwiderstand*
algebraic symbol	*Formelzeichen*
alkali	*Lauge*
alkane	*Alkan*
alloy	*Legierung*
alpha-emitter	*Alpha-Strahler*

alpha-rays	*Alpha-Strahlen*
alternating current	*Wechselstrom*
alternating magnetic field	*magnetisches Wechselfeld*
aluminium	*Aluminium*
ammonia	*Ammoniak*
ampere-hourage	*Ladekapazität*
amplification	*Verstärkung*
amplify	*verstärken*
amplitude	*Amplitude*
angle	*Winkel*
angstrom	*Angström*
angular acceleration	*Drehbeschleunigung*
angular frequency	*Kreisfrequenz*
angular momentum	*Drehimpuls*
angular velocity	*Winkelgeschwindigkeit*
animal matter	*tierischer Rohstoff*
annihilation	*Vernichtung*
anti-matter particle	*Anti-teilchen*
anti-nucleon	*Anti-Nukleon*
apparent power	*Scheinleistung*
appliance	*Gerät*
area	*Fläche, Flächeninhalt*
arithmetic unit	*Rechenwerk*
artificial intelligence	*künstliche Intelligenz*
assembly	*Montage*
atmospheric humidity	*Luftfeuchtigkeit*
atom	*Atom*
atomic bomb	*Atombombe*
atomic bond	*Atombindung*
atomic oscillation	*Atomschwingung*
attenuated wave	*gedämpfte Welle*
attenuation	*Dämpfung*
attractive force	*Anziehungskraft*
audio-transistor	*NF-Transistor*
auger bit	Schlangenbohrer

auto-electrician	*Autoelektriker*
auto-electrics	*Autoelektrik*
automatic gears	*Automatik*
Avogadro Constant	*Avogadro-Konstante*
axis	*Achse*
axle	*Achse*
back emf	*Gegenspannung*
ball bearing	*Kugellager*
bandwidth	*Empfangsbereich*
base current	*Basisstrom*
basic quantity	*Basisgröße*
basicity	*Basenstärke*
battery capacity	*Batteriekapazität*
battery cell	*Zelle*
battery stopper	*Batteriestöpsel*
battery terminal	*Batteriepol*
bearing	*Lager*
belt	*Riemen*
beta-particle	*ß-Teilchen*
beta-ray	*ß-Strahlen*
binary digit	*Binärzeichen*
binding forces	*Bindungskräfte*
bit	*Bit*
boiling point	*Siedepunkt*
bonding forces	*Bindungskräfte*
boring tool	*Bohrer*
brake failure	*Bremsversagen*
brake hydraulics	*Bremshydraulik*
brake lines	*Bremsleitungen*
brake system	*Bremsanlage*
braking efficiency	*Bremsleistung*
braking torque	*Bremsmoment*
brass	*Messing*
breakdown voltage	*Durchbruchspannung*
bridge rectifier	*Brückenschaltung*

brightness	*Helligkeit*
broadcast	*senden*
bush	*Buchse*
cable strippers	*Isolierzange*
calculator	*Taschenrechner*
cam	*Nocken*
carbon	*Kohlenstoff*
carburettor jet	*Vergaserdüse*
carburettor tuning	*Vergasereinstellung*
case	*Gehäuse*
catalyst	*Katalysator*
catalyst converter	*Katalysator*
cathode	*Katode*
cell	*Zelle*
central processing unit	*Zentraleinheit, CPU*
ceramic	*keramisch*
chain	*Kette*
chain reaction	*Kettenreaktion*
chain-drive	*Kettenantrieb*
channel selector	*Senderwahltaste*
characteristic	*Kennlinie*
charge	*Ladung*
charge polarity	*Ladungsvorzeichen*
chemicals	*Chemikalien*
chemical element	*chemisches Element*
chemical equation	*Reaktionsgleichung*
chemical formula	*chemische Formel*
chemical process	*chemisches Verfahren*
chemical symbol	*chemisches Symbol*
chemistry	*Chemielehre*
chip	*Chip*
chisel	*Meißel*
choke	*Choke*
choke	*Spule, Drosselspule*
chromium	*Chrom*

circuit	*Schaltung, Schaltkreis*
circuit board	*Schaltplatte*
circuit breaker	*Unterbrecher*
circuit component	*Schaltelement*
circuit symbol	*Schaltsymbol*
circuitry	*Schaltungen*
circular orbit	*Kreisbahn*
clamping fixture	*Spannzeug*
cloud chamber	*Nebelkammer*
co-ordinate	*Koordinate*
coaxial cable	*Koaxialleitung*
code	*Programmiersprache*
cog	*Zahnrad*
cold-start	*Kaltstart*
collision	*Zusammenstoß*
combustible substance	*Brennstoff*
command statement	*Befehl*
component	*Bauteil*
compound	*Verbindung*
compression stroke	*Verdichtungstakt*
computation	*EDV*
condenser	*Kondensator*
conductance	*Leitfähigkeit*
conducting state	*Durchlaßzustand*
conduction	*Leitung*
conductor	*Leiter*
connecting rod	*Pleuel*
conservation law	*Erhaltungssatz*
contact	*Kontakt*
contact breaker	*Unterbrecherkontakt*
contaminant	*Fremdkörper*
contrast	*Kontrast*
control character	*Steuerzeichen*
control circuit	*Steuerkreis*
control current	*Steuerstrom*

convection	*Konvektion, Wärmeströmung*
conventional current	*technische Stromrichtung*
cooker	*Herd*
coolant	*Kühlflüssigkeit*
cooling efficiency	*Kühlleistung*
copper	*Kupfer*
core	*Kern*
crankshaft	*Kurbelwelle*
crystal	*Kristall*
crystal lattice	*Kristallgitter*
current	*Strom*
current phase	*Stromphase*
current source	*Stromquelle*
current surge	*Stromstoß*
cycle	*Periode*
cylinder bore	*Zylinderdurchmesser*
damped oscillation	*gedämpfte Schwingung*
dashboard	*Armaturenbrett*
data	*Daten*
data file	*Datei*
data flow	*Datenfluß*
data item	*Datum*
data medium	*Datenträger*
data record	*Datensatz*
dc	*Gleichstrom*
decay sequence	*Zerfallsreihe*
decay time	*Zerfallszeit*
decaying radio-substance	*zerfallender Stoff*
deceleration	*Verzögerung*
deformation	*Verformung*
delay	*Verzögerung*
denominator	*Nenner*
density	*Dichte*
depletion region	*Sperrschicht*
deposits	*Ablagerungen*

derived quantity	*abgeleitete Größe*
deuterium	*Deuterium*
device	*Bauelement, Gerät*
diamond	*Diamant*
diaphragm	*Membrane*
dielectric	*Dielektrikum*
diffential gearing	*Differentialgetriebe*
dilute alkali	*verdünnte Lauge*
dimension	*Dimension*
dimensional accuracy	*Maßgenauigkeit*
diode	*Diode*
direction	*Richtung*
direction of rotation	*Richtungssinn*
directional microphone	*Richtmikrophon*
disc	*Scheibe*
discharge	*entladen*
discrete component	*diskretes Bauelement*
disk	*Platte*
diskette	*Diskette*
diskette drive	*Diskettenlaufwerk*
dissipation	*Wärmeabgabe*
distance	*Entfernung, Abstand*
distortion site	*Störstelle*
distributor	*Zündverteiler*
donor	*Donator*
dope	*dotieren*
drag	*Widerstand*
drill chuck	*Bohrerfutter*
drive	*Laufwerk*
drive dog	*Mitnehmer*
drive shaft	*Antriebswelle*
drum	*Trommel*
elastic impact	*elastischer Stoß*
elasticity modulus	*Elastizitätsmodul*
electric charge	*elektrische Ladung*

electric motor	*Elektromotor*
electric shock	*Stromschlag*
electrical appliance	*Elektrogerät*
electrical energy	*elektrische Energie*
electrical flux density	*elektrische Flußdichte*
electrical potential	*Potential*
electrical quantity	*elektrische Größe*
electrician	*Elektriker*
Electricity Board	*Strombehörde*
electricity generating plant	*Kraftwerk*
electricity meter	*Stromuhr*
electrochemical series	*Spannungsreihe*
electrode	*Elektrode*
electrolysis	*Elektrolyse*
electrolyte	*Elektrolyt*
electrolytic dissociation	*elektrolytische Zerlegung*
electron	*Elektron*
electron cloud	*Elektronengas*
electron deficiency	*Elektronenmangel*
electron mobility	*Elektronenbeweglichkeit*
electron shell	*Elektronenschale*
electron vacancy	*Elektronenlücke*
electronic switch	*elektronischer Schalter*
elementary particle	*Elementarteilchen*
elliptical orbit	*Ellipsenbahn*
emitter	*Emitter*
energy	*Energie*
energy release	*Energieabgabe*
energy source	*Energiequelle*
engine	*Motor*
engine compartment	*Motorraum*
engine cylinder	*Zylinder*
engine performance	*Motorleistung*
engine speed	*Drehzahl*
engine tuning	*Motoreinstellung*

engineering	*Technik*
engineering material	*Werkstoff*
equation	*Gleichung*
equation of state	*Zustandsgleichung*
equivalent circuit	*äquivalenter Stromkreis*
etch	*ätzen*
extrinsic conductivity	*Störstellenleitfähigkeit*
extrinsic material	*dotierter Halbleiter*
fan belt	*Keilriemen*
fatigue strength	*Dauerfestigkeit*
faucet	*Wasserhahn*
feed pressure	*Förderdruck*
feedback	*Rückkoppelung*
feeler gauge	*Fühlerlehre*
fet	*Feldeffekttransistor*
filament	*Glühfaden*
filament lamp	*Glühlampe*
filter	*Filter*
filter element	*Filtereinsatz*
firing order	*Zündfolge*
firing stroke	*Arbeitstakt*
fissile material	*spaltbare Materie*
fission	*Kernspaltung*
fixed program	*Festprogramm*
flexibility	*Biegsamkeit*
flipflop	*Flipflop*
float	*Schwimmer*
floppy drive	*Floppydisk-Laufwerk*
fluid	*Flüssigkeit*
fluid level	*Flüssigkeitsstand*
fluorescent lamp	*Leuchtstofflampe*
fluorescent screen	*Leuchtschirm*
flywheel	*Schwungrad*
foam	*Schaumstoff*
fog lamp	*Nebellampe*

footbrake	*Fußbremse*
force	*Kraft*
force component	*Teilkraft*
force of impact	*Stoßkraft*
force polygon	*Krafteck*
formula	*Formel*
forward voltage	*Durchlaßspannung*
fossil fuel	*fossiler Brennstoff*
freezing point	*Gefrierpunkt*
frequency	*Frequenz*
friction	*Reibung*
friction coefficient	*Reibungszahl*
frictional resistance	*Reibungswiderstand*
front axle	*Vorderachse*
front windscreen	*Frontscheibe*
fuel	*Kraftstoff, Treibstoff*
fuel consumption	*Kraftstoffverbrauch*
fuel injection	*Kraftstoffeinspritzung*
fuel lines	*Kraftstoffleitungen*
fuel sensor	*Kraftstoffgeber*
fuel/air ratio	*Kraftstoff/Luft-Verhältnis*
function	*Funktion*
fundamental oscillation	*Grundschwingung*
fuse	*Schmelzsicherung*
gain	*Verstärkungsfaktor*
gamma-rays	*Gamma-Strahlen*
gas	*Gas*
gasket	*Dichtung*
gate	*Gate*
gearbox	*Schaltwerk, Getriebe*
gearbox housing	*Getriebegehäuse*
gear-change	*Gangschaltung*
gear lever	*Schalthebel*
generator	*Generator*
generator	*Lichtmaschine*

gimlet	*Holzbohrer*
gradient	*Neigung*
graphics	*Grafik*
gravitational force	*Gravitationskraft, Schwerkraft*
gravity	*Gewichtskraft*
grease	*Schmierfett*
grease gun	*Schmierpistole*
grid	*Gitter*
grind wheel	*Schleifscheibe*
grinding machine	*Schleifmaschine*
group number	*Gruppenzahl*
hair dryer	*Fön*
half-life	*Halbwertszeit*
hand tool	*Handwerkzeug*
hard disk	*Festplatte*
hardware	*Hardware*
harmonic oscillation	*Oberschwingung*
head rest	*Kopfstütze*
heat	*Wärme*
heat engine	*Wärmekraftmaschine*
heat sink	*Kühlkörper*
heated cathode	*Glühkathode*
hexagonal nut	*Sechskantmutter*
hole	*Loch*
horizontal hold	*Zeilenfang*
horsepower	*Pferdestärke, PS*
hose	*Schlauch*
host atom	*Atomrumpf*
household appliance	*Haushaltsgerät*
household wiring	*Verkabelung*
HT	*Hochspannung*
HT-lead	*Zündleitung*
hull	*Schiffsrumpf*
hydraulic circuit	*Bremskreis*
hydrogen	*Wasserstoff*

hydrogen ion	*Wasserstoffion*
hyperbola	*Hyperbel*
hyperbolic path	*Hyperbelbahn*
IC	*integrierte Schaltung, IC, IS*
IC module	*IC-Modul*
idle	*leerlaufen*
idling screw	*Leerlaufeinstellschraube*
idling speed	*Leerlaufdrehzahl*
ignition	*Zündung*
ignition coil	*Zündspule*
ignition lead	*Zündkabel, Zündleitung*
immediate neighbour	*Nachbaratom*
impact	*Stoß*
impedance	*Impedanz, Widerstand*
imperfection	*Störstelle*
implement	*Werkzeug*
impulse	*Kraftstoß*
impurity	*Fremdkörper*
impurity atom	*Fremdatom*
induced nuclear reaction	*künstliche Kernreaktion*
inductance	*Induktivität*
inductive reactance	*induktiver Blindwiderstand*
inductor	*Spule, Induktor*
inertia	*Trägheit*
initial substance	*Ausgangsstoff*
inorganic chemistry	*anorganische Chemie*
input	*Eingabe*
input impedance	*Eingangswiderstand*
input peripheral	*Eingabegerät*
instantaneous power	*Momentanleistung*
instruction	*Befehl, Instruktion*
instrument	*Instrument*
insulation	*Isolierung*
insulator	*Isolierstoff*
intake valve	*Saugventil*

integer	*ganze Zahl*
integral calculus	*Integralrechnung*
integrated circuit	*integrierte Schaltung*
interference	*Störungen*
interference suppression	*Entstörung*
intrinsic conduction	*Eigenleitung*
intrinsic semiconductor	*reiner Halbleiter*
intrinsic silicon	*reines Silizium*
iodine	*Jod*
ion	*Ion*
ion core	*Atomrumpf*
ionic bond	*Ionenbindung*
ionised gas	*Ionengas*
ionised particle	*Ion*
ionising radiation	*radioaktive Strahlung*
iron	*Eisen*
iron core	*Eisenkern*
isotope	*Isotop*
jack	*Wagenheber*
jack plug	*Klinkenstecker*
job	*Job*
joint	*Gelenk*
joystick	*Joystick*
jump-start lead	*Starthilfekabel*
junction	*Übergang*
junction region	*Sperrschicht*
keyboard	*Tastatur*
kinetic energy	*kinetische Energie*
knob	*Drehregler*
laminated windscreen	*Verbundglas-Windschutzscheibe*
lamp	*Lampe*
lathe	*Drehmaschine*
lattice atom	*Gitteratom*
lattice electron	*Gitterelektron*
lattice site	*Gitterstelle*

LDR	*Fotowiderstand, LDR*
lead	*Kabel*
LED	*Leuchtdiode, LED*
lever	*Hebel*
leverage	*Hebelwirkung*
lifting gear	*Hebeeinrichtung*
light aperture	*Lichtfenster*
light bulb	*Glühbirne*
light ray	*Lichtstrahl*
light switch	*Lichtschalter*
light wave	*Lichtwelle*
light-sensitive	*lichtempfindlich*
lighting	*Beleuchtung*
line of application	*Wirkungslinie*
lining	*Belag*
litmus	*Lackmus*
load	*Last*
load current	*Laststrom*
lock nut	*Gegenmutter*
loft	*Dachspeicher*
logic circuit	*Logikschaltkreis*
LSI module	*hochintegriertes Bauelement, LSI-Modul*
lubricant	*Schmiermittel*
machine code	*Maschinensprache*
machine tool	*Werkzeugmaschine*
machine word	*Word*
machinery	*Maschinen*
machining	*spanende Formung*
magnetic field	*Magnetfeld*
magnetic field intensity	*magnetische Feldstärke*
magnitude	*Größe, Größenbetrag*
mainframe	*Mainframe*
mains frequency	*Netzfrequenz*
mains plug	*Stecker*
mains socket	*Steckdose*

mains source	*Netzanschluß*
mains voltage	*Netzspannung*
maintenance	*Wartung*
manganese	*Mangan*
manual	*Handbuch*
manual switch	*Schalter*
mass	*Masse*
mass number	*Massenzahl*
material	*Werkstoff*
matter	*Materie*
mean	*Durchschnitt*
measuring instrument	*Meßgerät, Meßinstrument*
mechanic	*Mechaniker*
mechanics	*Mechanik*
mechanical quantity	*mechanische Größe*
medium wave	*Mittelwelle*
melting point	*Schmelzpunkt*
member	*Glied*
memory	*Speicher*
memory cell	*Speicherzelle, Speicherelement*
mesh	*ineinandergreifen*
metal	*Metall*
metallic bond	*Metallbindung*
methane	*Methan*
microcomputer	*Mikrocomputer*
microwave	*Mikrowelle*
miniaturisation	*Verkleinerung*
minicomputer	*Kleincomputer*
mixture	*Gemisch, Gemenge*
mobile charge carrier	*freier Ladungsträger*
mobile ion	*frei bewegliches Ion*
mobility	*Beweglichkeit, Mobilität*
mode	*Betriebsrichtung*
module	*Modul*
mol	*Mol*

moment	*Moment*
momentum	*Impuls, Momentum*
monitor	*Monitor*
monitor screen	*Bildschirm*
monocrystal	*Einkristall*
mosfet	*Mosfet*
motor	*Motor*
mouse	*Maus*
multivibrator	*Multivibrator*
muon	*Müon*
n-type material	*n-Halbleiter*
n-type region	*n-Schicht, n-Zone*
needle	*Nadel, Zeiger*
negative terminal	*Minuspol*
neutron	*Neutron*
noble element	*Edelelement*
node	*Knote*
npn-transistor	*npn-Transistor*
nuclear disintegration	*Kernzerfall*
nuclear fission	*Kernspaltung*
nuclear forces	*Kernbindungskräfte*
nuclear fusion	*Kernfusion*
nuclear power	*Kernkraft*
nuclear power station	*Kernkraftwerk*
nuclear radiation	*Kernstrahlung*
nuclear technology	*Kerntechnik*
nuclear transmutation	*Kernumwandlung*
nucleon	*Nukleon*
nucleus	*Atomkern*
nuclide	*Nuklid*
nut	*Schraubenmutter*
octane	*Oktanzahl*
ohm	*Ohm*
on/off switch	*Ein/Aus-Schalter*
operational amplifier	*IC-Verstärker*

Periodic Table	*Periodensystem*
peripheral	*Peripheriegerät*
personal computer	*PC*
petrol	*Benzin*
petrol feed	*Benzinnachschub*
pH	*pH-Wert*
phase	*Phase*
phase angle	*Phasenwinkel*
phase shift	*Phasenverschiebung*
phasor	*Phasenzeiger, Phasenvektor*
phasor diagram	*Zeigerdiagramm*
phosphorus	*Phosphor*
photon	*Photon*
photosensitive device	*lichtempfindliches Bauelement*
physical constant	*physikalische Konstante*
physical quantity	*physikalische Größe*
pick-up	*Tonabnehmer*
pion	*Pion*
pipe	*Leitung*
piston	*Kolben*
piston stroke	*Hub*
pitch control	*Plattengeschwindigkeitsregler*
pitchblende	*Pechblende*
planar represention	*zweidimensionale Darstellung*
plasma	*Plasma*
plastic	*Kunststoff*
pliers	*Zange*
plotter	*Plotter*
plug	*Stecker*
plug spanner	*Zündkerzenschlüssel*
plunger	*Kolben*
pn-junction	*pn-Übergang*
pneumatic brake	*Luftbremse*
pnp-transistor	*pnp-Transistor*
pnpn switching device	*Vierschichtdiode*

pocket calculator	*Taschenrechner*
polarity	*Vorzeichen*
polymer	*Polymer*
poor conductor	*schlechter Leiter*
positive carrier	*positiver Ladungsträger*
positive ion core	*positiver Atomrumpf*
positive terminal	*Pluspol*
positron	*Positron*
potential	*Energiepotential*
potential	*Spannungspotential*
potential barrier	*Potentialschwelle*
potential difference	*Spannungsunterschied*
potential energy	*potentielle Energie, Lageenergie*
potentiometer	*Potentiometer, Drehwiderstand*
power	*Leistung*
power cord	*Netzkabel*
power dissipation	*Wärmeabgabe*
power distribution network	*Stromnetz*
power hyperbola	*Leistungshyperbel*
power loss	*Verlustleistung*
power network	*Stromnetz*
power plant	*Stromkraftwerk*
power rating	*Leistungsbetriebswert*
power socket	*Steckdose*
power source	*Stromquelle*
power stage	*Leistungsstufe*
power station	*Kraftwerk*
power supply	*Stromversorgung*
power transmission authorities	*Stromenergiebehörde*
power unit	*Netzteil*
pressure	*Druck*
pressure-sensitive device	*Drucksensor*
primary current	*Primärstrom*
printed circuit	*gedruckte Schaltung*
processing time	*Rechenzeit*

processor	*Prozessor*
production line	*Fließband*
program	*Programm*
propane	*Propan*
propulsion	*Antrieb*
protium	*Protium*
proton	*Proton*
pulley	*Rolle, Riemenscheibe*
pulse	*Impuls*
pump	*Pumpe*
push-button	*Drucktaste*
pushrod	*Stößel*
quantum	*Quant*
quantum mechanics	*Quantenmechanik*
quark	*Quark*
radian	*Radiant*
radiation	*Strahlung*
radiation dose	*Strahlungsenergiedosis*
radiator hose	*Kühlerschlauch*
radio ham	*Rundfunkamateur*
radio transmitter	*Radiosender*
radio wave	*Radiowelle*
radio-element	*radioaktives Element*
radio-sample	*radioaktives Präparat*
radio-substance	*radioaktive Substanz*
radioactive decay	*radioaktiver Zerfall*
radioactivity	*Radioaktivität*
radiochemical equation	*Reaktionsgleichung*
radiochemistry	*Radiochemie*
railway	*Eisenbahn*
RAM	*RAM*
rate	*Häufigkeit, Geschwindigkeit*
rating	*Betreibswert*
raw material	*Rohstoff*
rays	*Strahlen*

RMS voltage	*Effektivspannung*
robot technology	*Robotertechnik*
rocket	*Rakete*
rod	*Stab, Stange*
roof aerial	*Dachantenne*
rotational energy	*Drehenergie*
rotational momentum	*Drehimpuls*
rotational speed	*Drehzahl*
rotational velocity	*Drehgeschwindigkeit*
rotor	*Läufer*
rust-protection compound	*Rostschutzmittel*
salt	*Salz*
saturation	*Sättigung*
scalar	*Skalargröße*
screw	*Schraube*
semiconductor	*Halbleiter*
semiconductor component	*Halbleiterbauelement*
sensor	*Sensor, Meßfühler*
series	*Reihe*
series connection	*Reihenschaltung*
servo-unit	*Servoeinheit*
shaft	*Welle*
shear strength	*Scherfestigkeit*
shear stress	*Scherspannung*
sheet metal	*Stahlblech*
shock absorber	*Stoßdämpfer*
short-circuit	*Kurzschluß*
SI-unit	*SI-Einheit*
signal	*Signal*
signal transmission	*Signalübertragung*
silicon	*Silizium*
silicon chip	*Chip*
silicon wafer	*Wafer, Scheibe*
sinusoidal waveform	*Sinuswelle*
site	*Gitterstelle*

strain	*Dehnung*
stream	*Strömung*
streamlines	*Stromlinien*
stress	*mechanische Spannung*
stroke	*Hub, Takt*
strut	*Glied*
stylus	*Nadel*
substance	*Stoff, Substanz*
sulphur	*Schwefel*
supply voltage	*Betriebsspannung*
support arm	*Stütze*
suspension	*Aufhängung*
switch	*Schalter*
switching circuit	*Schaltkreis*
switching device	*Schaltelement*
switching IC	*integrierter Schaltkreis*
symmetry	*Symmetrie*
tandem circuit	*Zweikreissystem*
tank	*Tank*
technician	*Techniker*
television cable	*Fernsehkabel*
television set	*Fernsehapparat*
terminal	*Pol, Anschluß*
text processing	*Textverarbeitung*
theorem	*Lehrsatz*
thermal conductivity	*Wärmeleitfähigkeit*
thermal dissipation	*Wärmeabgabe*
thermal expansion	*Wärmedehnung*
thermal stress	*Wärmespannung*
thermionic tube	*thermionische Röhre*
thermistor	*Wärmewiderstand*
thermodynamics	*Wärmelehre*
throttle	*drosseln*
throttle valve	*Drosselklappe*
thrust	*Schubkraft*

upward thrust	*Auftriebskraft*
uranium	*Uran*
user	*User, Benutzer*
V-belt	*Keilriemen*
vacuum hose	*Unterdruckschlauch*
valency	*Valenz*
valency shell	*Valenzschale*
valve	*Röhre, Ventil*
valve rocker	*Kipphebel*
variable	*Variable*
VDU, visual display unit	*Bildschirmeinheit*
vegetable matter	*pflanzlicher Rohstoff*
vehicle	*Fahrzeug*
velocity	*Geschwindigkeit*
vertical hold	*Bildfang*
vessel	*Behälter*
vibration	*mechanische Schwingung*
voltage	*elektrische Spannung*
voltage cycle	*Spannungsperiode*
voltage regulation	*Spannungsstabilisierung*
voltage waveform	*Spannungswelle*
volume	*Volumen*
volume control	*Lautstärkeregler*
wall	*Mauer*
washing machine	*Waschmaschine*
water vapour	*Wasserdampf*
wattage	*Wattleistung*
wave	*Welle*
wave mechanics	*Wellenlehre*
wave packet	*Wellenbündel*
wave propagation	*Wellenfortpflanzung*
waveband	*Wellenbereich*
weight	*Gewicht*
weld	*schweißen*
weld joint	*Schweißverbindung, Schweißstoß*

GLOBAL INDEX

BIBLIOGRAPHY

The following list of dictionaries and technical reference books is suitable for translators into English, especially beginners. All are available in low-price paperback editions and are revised regularly. Readers concerned with German are advised to consult the Bibliography section of Volume 2.

1. CHAMBERS W & R., *Dictionary of Science and Technology*, Edinburgh, (2 volumes).

2. LETTS, C. *Dictionary of Mathematics*
   Dictionary of Physics
   Dictionary of Chemistry
   Of the series *Letts Key Facts*, Charles Letts & Co Ltd, London/-Edinburgh/New York.

3. CLARKE, J.S. (1986) *Teach Yourself Applied Chemistry*, Hodder & Stoughton, Sevenoaks, U.K.

4. EDITORS of EEE Magazine, *Electronic Circuit Design Handbook*, W. Foulsham & Co., Slough, U.K. (revised annually).

5. *HAYNES Owners Workshop Manual* (series, all European/Japanese car models, e.g. *Opel Cadet, Ford Fiesta, Volkswagen Transporter*) Haynes Publishing Group, Yeovil, U.K.

6. *Questions & Answers*, series - including the titles:

Automobile Electrics	*Automobile Engines*	*Brickwork*
Boat Construction	*Car Body Care*	*Colour Television*
Diesel Engines	*Electric Motors*	*Electric Wiring*
Electricity	*Electronics*	*Gas Welding*
Hi-Fi	*Integrated Circuits*	*Lathework*
Plumbing	*Refrigeration*	*Transistors*

NEWNES Technical Books, Sevenoaks, U.K.

APPENDIX

General, Technical, Computational Linguistics

It has been an ambitious project to describe the underlying concepts of the vast spectrum of industrial and scientific technology in such a relatively small book but this goal has been achieved by "compressing" the maximum semantic information into the structure of the book itself. This section indicates the recommended access approach for German/English translators faced with particular problems in translation. For those readers not concerned with German and hence less likely to purchase Volume 2, it gives an impression of what they are missing. Such readers may be inspired to produce Technical Thesauri, Polyseme and Collocational Dictionaries for other languages - Italian, Japanese, Russian etc, provided that they have appropriate *software* facilities. Hopefully, this book may also inspire professional software-package designers.

Three sections follow, headed *Accessing* Techniques, *Linguistics* and *Computation*. The first section is the most important from the viewpoint of the translator, and is divided into 9 subsections concerned with rapid access to terminological information. The remaining sections are intended for general linguists and computer scientists respectively, who may have browsed through this book for their own interests.

1 Accessing Techniques

The book can be read on two levels. Volume 1 makes interesting "light reading" for a student translator or a professional translator with a non-technical background. Having read the book, a professional translator faced with a practical problem concerning a misleading term can rapidly locate any specific information he needs via the Global Index, which provides the appropriate Chapter Section or Term List. Similar information appears in a highly condensed form in the Technical Thesaurus, where terms such as *set* have separate entries for different usages, for instance

set (Mathematics - subset, etc):	*Menge,-f*
set (TV/radio set):	*Apparat,-m*
set (keyboard characters):	*Satz,-m*

These two glossaries provide the best guide to the technical polysemy of English. German polysemes are apparent directly in the Polyseme Dictionary, where compounds involving the same root, such as

Stoß:	impact, surge, joint
Platte:	disc, disk, board
Dämpfer:	absorber, baffle, damper, muffler
Element:	component, device, element, sensor
Modul:	module, modulus

occur adjacently - *Kraftstoß*, *Stromstoß*, *Schweißstoß*, etc.

A variety of other problems commonly encountered by technical translators, many of which are extremely frustrating for linguists equipped only with *conventional* alphabetic dictionaries, are quickly resolved by appropriate use of this book with its counterpart Volume 2. The following sections offer guidelines for the rapid efficient accessing of information and the specification of more complex technical concepts, which do not appear explicitly in the book.

The recommended access technique depends on the nature of the problem - whether it concerns: *terminology*, *lexis* (general vocabulary), *syntax*, *style*, *polysemy*, *homonymy*, *hyponymy*, *antonymy*, *synonymy*, *definition*, *context*, etc. Often the problem results from combinations of the above aspects. Examples of particular linguistic problems occurring in translation, and the advisable approach in using this book follow.

1.1 Term Selection

Let us assume that a translator is uncertain how to render the German *Widerstand* correctly in a particular text taken from the field of *Electric Motors:*

1) The Polyseme Dictionary provides six possible translations: *drag*, *impedance*, *reactance*, *resistance*, *resistivity*, *resistor*. These terms are translations of *Widerstand* in specific compounds such as *Fotowiderstand*, *Scheinwiderstand*, *Luftwiderstand.*
2) The Field Codes of the respective entries in the Polyseme Dictionary reveal that *drag* does not occur in an electrical context. This narrows the options to five.
3) The Global Index reveals several occurrences of each term in Volume 1 and the translator realises that sections 2.2 and 2.6 are the ones he needs. He briefly consults the sections concerned and eliminates *reactance*, *resistivity* and *resistor*. Two alternatives remain: *impedance*, *resistance.*
4) Chapter 2 leads him to Fig.2A, an alphabetic list of electrical parameters, which provides the information that *resistance* is a *scalar* quantity but *impedance* may be represented as a *phasor*. (If he has forgotten the distinction *scalar/phasor* he simply uses the Global Index again.) This eliminates *resistance.*
5) Finding no contradicting situation in the Thesaurus he translates *Widerstand* as *impedance* with a clear conscience.

1.2 Lexis, Syntax

In addition to concept recognition and terminology, translators often have problems with simple, every-day expressions which have a precise rendering in a particular technical context. For instance, the use of the word *stark* in the following expressions :

stark beschleunigt	rapidly accelerated
stark geneigt	sharply inclined
stark maschinenorientiert	heavily machine-biassed
stark aufeinanderprallen	to collide violently
starke Schwingungen	large oscillations
starke Magnetfelder	powerful magnetic fields
starke Veränderungen	substantial changes

An inexperienced German translator who simply substitutes the word *strong* in such cases will inevitably produce very misleading translations. Yet conventional dictionaries are often of little use here. What the translator really needs is access to examples of similar situations illustrating possible translations of words like *stark* in different contexts.

The Collocation Dictionary can assist the translator in this problem, where specific sentences, accessed alphabetically in order of particularly troublesome general words, such as *stark*, provide a constant source of reference. Most of the entries concern verbs, such as *abgeben*, *abspielen*, *abstimmen*, but there are also adjectives, prepositions and troublesome nouns, such as *Beschaffenheit*, *Weg*, *Größe*. If the Chapters have been studied carefully the reader will have no difficulty in determining the particular context of each sentence and may narrow the number of alternatives in a professional translation to just one.

This Dictionary also indirectly provides information on *separable verb prefixes*, *paraphrasing*, *adverbial phrases* and other syntactic problems which make it difficult for non-native English speakers to correctly translate into English.

1.3 Synonymy

True synonyms rarely survive for long in technical fields because the rate of expansion of concepts generally vastly exceeds the growth rate of the language. When they do survive it is usually because one is a layman term (Spannung = *volts*) and the other the standard term (Spannung = *voltage*), but sometimes they arise due to attempts within the field to make the terminology more symmetrical. The original electrical terms *condenser/capacity* were replaced by the now standard *capacitor/capacitance* to provide lexical compatibility with the closely associated concepts *resistor/resistance* and *inductor/inductance*. Substandard terms are mentioned in Volume 1 only in passing and obsolete terms (Spannung = *electrical tension*) are mainly ignored. The best guide to synonyms is the Thesaurus, where five categories are distinguished: *s/ns/cs/ls/os*, corresponding to "true, near, contextual, layman, obsolete synonym of". For instance:

head, s: cylinder head (Automobiles)
atomic bond, cs: molecular bond (Materials Science)
capacity, os: capacitance (Electronics)

1.4 Hyponymy

Hyponymy and other semantic associations between terms are discussed in Chapter 12 in connection with the hierarchic organisation of terminology. The Thesaurus employs descriptors for both *generic* and *partitive* relations: *t* ("type of") and *p* ("part of")

sleeve, t:seal; u: grease.	*Manschette,-f*
mark, p: scale; u: meter, gauge.	*Strich,-m*

and there are many more, such as *u* (*used in connection with*), *cv* (*covers*), *co* (*consists of*), *ex* (*example*):

switch, cv: toggle/rotary switch	*Schalter,-m*
atom, co: nucleus, electron shells	*Atom,-n*
valve, ex: release valve	*Hahn,-m*
performance, u: engine	*Leistung,-f*
power, u: energy	*Leistung,-f*

1.5 Antonymy, Contrast

Antonymy is observable in the terminological hierarchies but like synonymy, true antonymy rarely occurs in technical contexts, apart from trivial examples such as *positive/negative battery terminal*. Even terms which seem antonymous, such as the Nucleonics terms *negatron/positron* or *neutron/anti-neutron*, are not necessarily regarded by specialists as denoting truly opposite concepts in the sense of *black* and *white*. Since the term "antonym" is likely to introduce more confusion in technical contexts than it resolves, it is hardly used here.

Contrast, on the other hand, is a useful linguistic concept for specifying terminology. Indeed, the Technical Thesaurus employs an ontological descriptor *ct* - "contrasted with":

phase angle, ct: amplitude, frequency; u: waveform
atomic number, ct: mass number, valency; u: element
electron, ct: proton, neutron; u: atom

Possible antonyms (*n-type/p-type semiconductor*) appear only implicitly, as contrasts.

1.6 Polyonymy (British/American)

Fortunately, differences between British and American English in the *basic concepts* common to technical fields are virtually non-existent; they are hardly mentioned until Chapter 7. In some modern fields, such as Computer Engineering, the terminologies can be considered completely identical and spellings such as *program, disk, diskette* are now standard in both British and American. But in older fields - Automobile Technology, Railway/Railroad Engineering, Household Plumbing, there is still considerable variation.

The author is British; hence the syntax of the Chapters and the English translations of the sentences in the Collocation Dictionary. Important differences, such as the electrical terms *earth/ground* (Br/Am) are mentioned occasionally in the Chapters and summarised together with trivial spelling differences (such as: Br. *carburettor*; Am. *carburetor*) in the Term Lists and in the Global Index.

1.7 Homonymy, Polysemy

Occasionally the same *general term* is used in one language in similar contexts for very different concepts. For instance, the German *Satz*: *theorem*; *rule*; *law*; *principle*; *record*; *set*; *statement*; *phrase*; etc. Sometimes the terms are polysemes, that is they share the same "fundamental" meaning; for example, *Satz* in *Sinussatz* (sine rule) and *Impulssatz* (Law of Conservation of Momentum) are semantically related. In other cases the terms are homonyms, that is to say it is more or less pure coincidence that the same lexeme is used. The Computational terms *Datensatz* (data record) and *Zeichensatz* (character set) illustrate different occurrences of the homonyms *Satz*.

The distinction homonym/polyseme is of interest more to the linguistic theorist than to a translator and is not discussed further. Homonyms and polysemes are easy to locate in the Polyseme Dictionary, as they occur in different compounds adjacently. The "Field Codes" of the Dictionary enable the reader to make further broad generalisations, such as: *theorem*, *rule* (Mathematics); *law*, *principle* (Physics); *set*, *record* (Computing). Conceptual problems, the meanings of *momentum* or *sine* for instance, are resolved either by locating the concept description (Global Index) or by consulting the Thesaurus.

1.8 Style

Perhaps this book so far has reinforced the assumption of many literature graduates that "technical stylistics" does not exist. This is not strictly true. A good technical author tries to make his scientific reports, articles and text books as readable as possible and like any other author he will avoid the repetition of cumbersome terms, for instance the use of *Widerstand* as a substitute for: *Ohmscher Widerstand* (resistance), *Blindwiderstand* (reactance), *Scheinwiderstand* (impedance).

The terms available for stylistic improvements are strictly limited and vary from one language to another. In a German text concerning *transformers*, for example, the following terms may occur in the same sentence: *Gegenspannung*, *Primärspannung*, *Versorgungsspannung*. These can be translated as *back voltage*, *primary voltage*, *supply voltage*, respectively and the reader of the translation will not be misled, but not many translators realise that there is a stylistic alternative for *Gegenspannung*, namely *back emf* ("electro-motive force"). Similarly in other electrical contexts involving the concept *voltage* it is possible to substitute *potential*. This does not mean to say that *voltage*, *emf* and *potential* are synonymous. Each is defined separately but there are areas where these concepts overlap.

Stylistic alternatives are mentioned occasionally in Volume 1, and are accessible via the Global Index. They occur in the Dictionaries in lengthy compound terms, where the most frequent rendering is given. For instance, *Selbstinduktionsspannung*: *induced emf*. However, it is the Thesaurus which provides the best guide to stylistic alternatives, via the generic descriptor *t* ("type of") and the descriptors *ns*, *cs* (near, contextual synonym).

In view of the diversity of technical fields, very few professional translators ever reach the stage of improving their own terminological style. But this is not serious. Unlike the temptation to translate *Spannung* as *stress* or *tension* (mechanical concepts) in a completely electrical context: such blunders can neither be understood nor tolerated by native English speakers with no knowledge of German.

1.9 Writing Conventions

Just as English commercial correspondence seems to abide by slightly different grammatical rules to other areas of language so technical literature also has conventions of its own. Business letters frequently begin "If you *would* ..." which is very confusing for foreign speakers who have been taught that *would* does not occur in *if-clauses*. Similarly, non-native technical translators have little use for their torturous years spent in mastering English tenses. Technical literature is complex enough without the luxury of tenses and employs the *present tense* virtually throughout. The Collocation

Dictionary demonstrates this convincingly. Other aspects of technical style which are often difficult for non-native speakers (appropriate syntax, correct choice of prepositions, etc) can be acquired to a moderate degree also from the Collocation Dictionary.

2 Linguistics

Specialists in the area of General Linguistics frequently have difficulty in justifying theoretical models, particularly in the area of Semantics, since their examples are based on general vocabulary and are open to more than one interpretation. Technical terminology is defined non-ambiguously and therefore provides a better basis for academic discussion in certain linguistic areas.

Section 1.7 points out a number of homonyms and polysemes. Homophones, that is terms with identical pronunciation but different meanings, also occur in technical literature such as *ion/iron*, and there are homonyms which are not homophones, *lead* (Blei) and *lead* (Kabel). Although there are cases of technical English polysemes having the same German equivalent - *grid* (Ge. *Gitter*) in both mechanical and electrical senses (*ventilators/thermionic tubes*), they are unusual. There are some quite unexpected similarities in translation: the German chemical term *Base* is also *base* in English. And there are surprises: the German *Basis* in connection with *transistors* is not *basis* in English, but again *base*.

Other examples are quoted in the Chapters and there are more in the Thesaurus, Dictionaries and Global Index awaiting fresh "discovery". It is hoped, therefore, that this book will find its way onto the bookshelves of other linguists not involved in technical translation as such.

3 Computation

Recent years have witnessed repeated "terminological explosions" in many specialised fields and the need for concise structurally organised lexicographical data has never been so great. Software engineers have only recently designed efficient *packages* for *text processing* or assembling large terminological *data banks*, which are substitutes for type-writers and earlier card-indexes. These facilities need to be combined and improved to allow for reverse and conceptual sorting arrangements as well as simple alphabetic ones. Similar books by specialists in *commercial*, *legal* or *economics* translation or areas like *biochemistry*, *medicine*, *gene technology*, could then appear.

There is a ready market for computational lexicographical facilities and it is hoped that software designers and dictionary compilers might derive inspiration from the approaches offered here.