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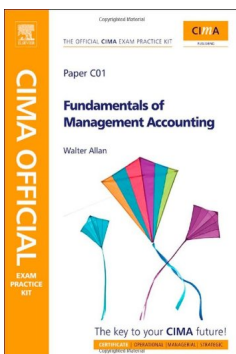
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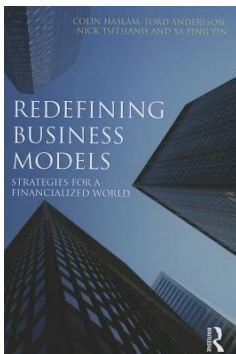
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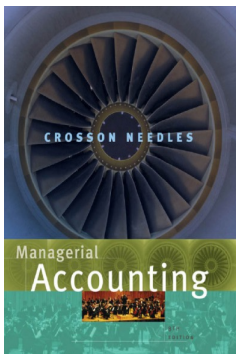
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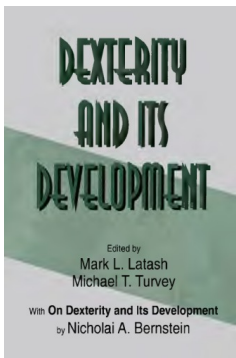
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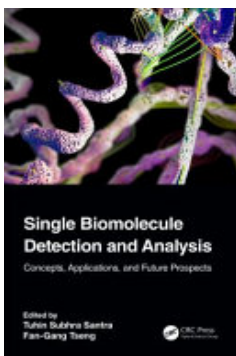
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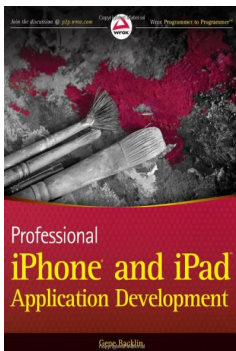
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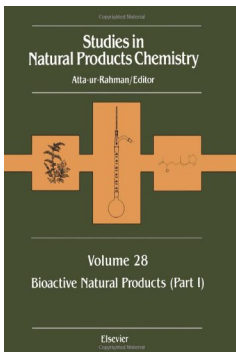
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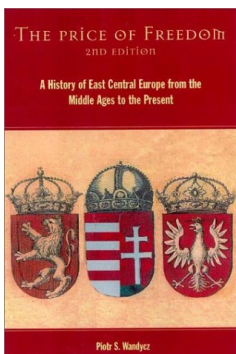
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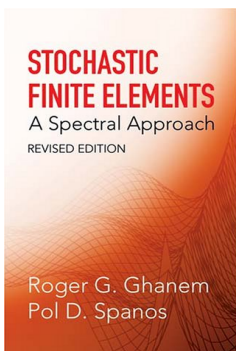
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IN MEMORIAM

Sadly, Professor Colin Drury passed away in 2019 after a short illness. At the time of his passing, Colin had already made plans for the content of the 11th edition of his bestselling textbook, *Management and Cost Accounting*. Therefore, in discussion with Colin's family, Cengage brought on board a new and highly experienced contributing author for the 11th edition, Professor Mike Tayles, to bring Colin's initial plans and drafts to conclusion, and Professor Mike Tayles has continued his dedicated work by updating the eighth edition of *Management Accounting for Business* which introduces the theory and practice of management accounting and emphasizes its role in how business decisions are made. The new edition of *Management Accounting for Business* addresses many of the latest key topics including digitalization and big data, environmental and sustainability issues, ethical considerations and the impact of the emergence of the knowledge-based economy.

For several decades, Colin Drury has been known for his textbooks on management accounting by almost anyone who wanted a thorough understanding of the subject. Colin was often complimented on the comprehensive nature and clarity of his writing. This was probably attributable to his previous practical experience, but also to the thorough and uncomplicated manner in which he tackled all his work. He managed to navigate successfully between the academic and practitioners' study of management accounting and as a result of his rigour and authority, his textbooks became recommended reading in management accounting by the professional accounting bodies as well as in many universities across the UK, Europe and beyond. From early on, his textbook *Management and Cost Accounting* was regarded as 'Europe's Bestselling Management Accounting Textbook'. The ACCA Students' Newsletter noted: 'Drury's book can be recommended, without reservation, to all accounting students.'

Colin also served on the Research Committee of CIMA and worked on the CIMA Official Management Accounting Terminology. Colin was quick to include the most up-to-date research findings into the latest editions of his textbooks and therefore helped turn research into practice. The areas of his own research interests emphasized current practice, hence, he helped to bring management accounting practice into research. Shortly after Colin's retirement, to acknowledge his achievements, the British Accounting and Finance Association bestowed upon him a Lifetime Achievement Award, which he richly deserved. Colin's legacy will live on through this award and through his extensive contributions to books and journals – Cengage thanks him for all his dedication over the past decades, and for his family's support in enabling the new editions of his textbooks to reach fruition.

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PREFACE

This new eighth edition of *Management Accounting for Business* builds upon the foundation of earlier editions which Colin so successfully developed. The book shows a level of comprehensive coverage and clarity of explanation for which Colin was justifiably renowned. Colin and I first started to teach together 40 years ago and commenced our collaboration in 1990 with research into management accounting practices producing professional research reports, academic journal papers and business articles. Colin was a pleasure to work with – he had a clear passion for this work, but for someone so renowned in the academic accounting community he was very modest about his achievements, there was always a humility in the way he went about all of his academic endeavours. Although our careers ultimately followed different paths, we always maintained contact and I am privileged to make a small contribution to this highly successful textbook.

The aim of this book is to provide an introduction to the theory and practice of management accounting and to emphasize its role in making business decisions. It is intended primarily for students who are not specializing in accounting and are pursuing a one- or two-semester basic management accounting course. The more advanced technical aspects that are required by specialist accounting students are not covered. These topics are examined in the author's successful book *Management and Cost Accounting*, the 11th edition of which is also published by Cengage EMEA.

Feedback from lecturers in a large number of universities indicated that they had found the content, structure and presentation of *Management and Cost Accounting* extremely satisfactory and most appropriate for accounting students pursuing a two-year management accounting course. They also indicated that there was a need for a book (based on *Management and Cost Accounting*) for students on shorter courses. This book meets that need and, while still comprehensive, is particularly suitable for students not specializing in accounting, studying management accounting on the following courses:

- a first-level management accounting course for undergraduate students
- higher national diploma in business and finance
- postgraduate introductory management accounting courses.

An introductory course in financial accounting is not a prerequisite, although many students will have undertaken such a course.

STRUCTURE AND PLAN OF THE BOOK

In writing this book we have adopted the same structure and included much of the introductory content of *Management and Cost Accounting*. The major theme is that different information is required for different purposes. The framework is based on the principle that there are three purposes of constructing management accounting information. One is conventional cost

accounting, with its emphasis on producing product costs for allocating costs between cost of goods sold and inventories to meet external and internal financial accounting inventory valuation and profit measurement requirements. The second is the notion of decision-relevant costs, with the emphasis on providing information to help managers make good decisions. The third is responsibility accounting, cost control and performance management, which focus on both financial and non-financial information, in particular the assignment of cost and revenues to responsibility centres. This book focuses mainly on the second and third of the above purposes. Less emphasis is given to conventional cost accounting, because an in-depth understanding of this topic is not essential for those students who are not specializing in accounting. The purposes are captured in Figure 0.1, and throughout the book we remind the reader of this distinction and point out where different management accounting information is, or is not, suited to particular circumstances.

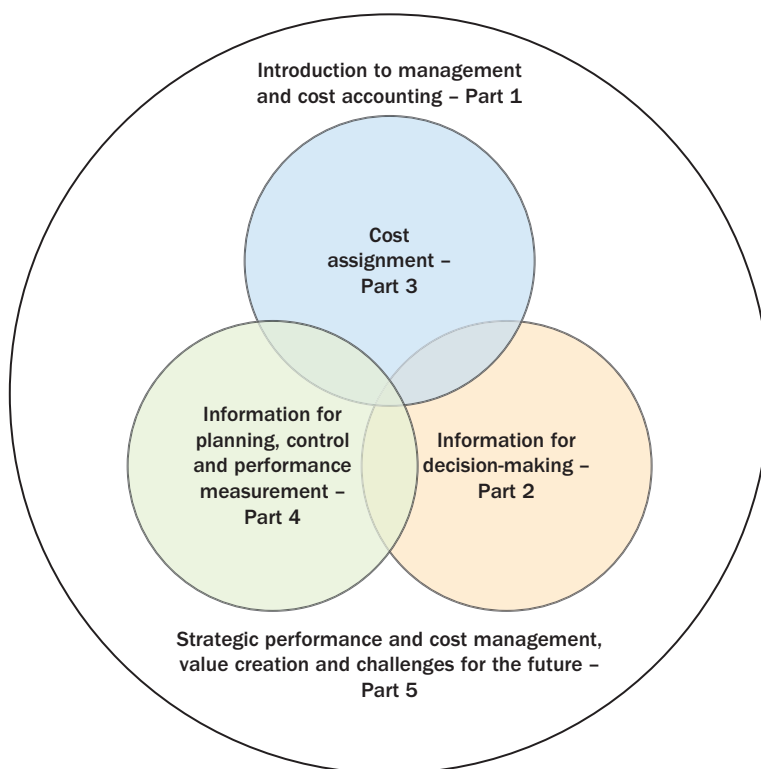


FIGURE 0.1

The management accounting system structure of this book

This book consists of 16 chapters divided into five parts. Part One contains two chapters and provides an introduction to management and cost accounting, the terminology and a framework for studying the remaining chapters. Part Two consists of four chapters and is entitled 'Information for decision-making'. Here the focus is on measuring and identifying those costs that are relevant for different types of decisions that managers and businesses are faced with. These include tactical decisions, pricing, profitability analysis, the impact of business volume, spare capacity and long-term decisions. The title of Part Three is 'Cost assignment'. It is made up of two chapters that provide an explanation of how costs are accumulated and assigned to cost objects, such as products or services. In particular, alternative approaches that can be used for measuring resources consumed by cost objects and the factors that should be considered in determining the sophistication of the cost accumulation system are described.

Part Four consists of five chapters and is entitled 'Information for planning, control and performance measurement'. This part concentrates on the process of translating organizational goals and objectives into specific activities and the resources that are required, via the short-term (budgeting) and long-term planning processes. The management control systems that organizations use are described and the role that management accounting control systems play within the overall control process, including performance measurement and evaluation within different segments of the organization, are examined. The title of Part Five is 'Strategic performance and cost management, value creation and challenges for the future'. It consists of three chapters. The first chapter focuses on strategic performance management, the second on strategic cost management and value creation. The third chapter concentrates on the emerging issues that are likely to have an impact on management accounting, and considers some potential future developments in management accounting. The five parts are displayed in Figure 0.1.

CHANGES IN THE CONTENT OF THE EIGHTH EDITION

The feedback relating to the structure and content of the previous editions has been extremely favourable and therefore no major changes have been made to the existing structure. The objective in writing the eighth edition has been to produce more accessible text and to incorporate recent developments in management accounting. All of the chapters have been reviewed, and where appropriate new material has been added. There is greater discussion related to digitalization and big data, environmental and sustainability issues, ethical considerations and the impact of the emergence of the knowledge-based economy. This occurs throughout the book, culminating in the final chapter which focuses on the emerging issues that are likely to have an impact on management accounting and considers some potential future developments in management accounting. Updates have been made to the end-of-chapter assessment material, and solutions to these are in a separate section at the end of the book. Most of the *Real World Views* that provide examples of the practical application of management accounting have been replaced by more recent examples or updated. Suggested answers to *Real World Views* questions are in the Instructor's Manual. Additionally, we have included a new and highly engaging *Apply your Knowledge* section at the end of each chapter which aims to reinforce the content and provide scope to consider its wider implications. This new feature is explained further in Chapter 1.

Learning notes

In order to meet the different requirements of readers and different course curricula, various topics are included as learning notes that can be accessed by students and lecturers on the digital support resources accompanying this book. The learning notes relate to either specific topics that may be only applicable to a minority of the readers or a discussion of topics where more complex issues are involved that not all readers may wish to pursue. All learning notes are appropriately cross-referenced within the text to the digital support resources. For example, at appropriate points within specific chapters, the reader's attention is drawn to the fact that, for a particular topic, more complex issues

exist and that a discussion of these issues can be found by referring to a specific learning note on the digital support resources accompanying this book.

Case studies

Case studies are available on the dedicated digital support resources for this book. Both lecturers and students can download these case studies from the digital support resources. Teaching notes for the case studies are only available for lecturers to download. The cases generally cover the content of several chapters and contain questions to which there is no ideal answer. They are intended to encourage independent thought and initiative and to relate and apply your understanding of the content of this book in more uncertain situations. They are also intended to develop your critical thinking and analytical skills.

International focus

The book has now become an established text in many different countries throughout the world. Because of this a more international focus has been adopted. A major feature is the presentation of boxed exhibits of surveys and practical applications of management accounting in companies in many different countries. To simplify the presentation, however, the UK pound monetary unit has been mostly used throughout the book, although examples of the euro, dollar and rand can be found in the assessment material at the end of each chapter. Most of the assessment material incorporates questions set within a UK context. These questions, however, are appropriate for worldwide use and contain the beneficial features described above for case study assignments.

Assessment material

Throughout this book we have kept the illustrations simple. You can check your understanding of each chapter by answering the review questions. Each review question is followed by page numbers within parentheses that indicate where in the text the answers to specific review questions can be found. More complex review problems are also set at the end of each chapter and within the digital online resources to enable students to pursue certain topics in more depth. Fully worked solutions to the review problems within the text are provided in a separate section at the end of the book.

SUPPLEMENTARY MATERIAL

The eighth edition of Colin Drury's *Management Accounting for Business* is accompanied by the following dedicated digital support resources:

- Dedicated instructor resources only available to lecturers, who can register for access either at account.cengage.com or by speaking to their local Cengage representative.
- Cengage MindTap helps students embed the material. Dedicated digital content creates a learning path designed by the instructor to guide students through the course and focus on what's important. Instructors can find out more about accessing MindTap by speaking to their local Cengage representative.

DEDICATED INSTRUCTOR RESOURCES

This includes the following resources for lecturers:

- **Instructor's Manual** with instructor's additional review problems
- **Online test bank** provides approximately 500 extra questions and answers
- **PowerPoint** slides to use in your teaching
- **Case studies** (internationally focused)
- **Teaching notes** to accompany the case studies
- **Downloadable figures and tables** from the book to use in your teaching.

MINDTAP

MindTap is an online learning solution that allows lecturers to customize and combine easily learning tools such as readings, interactive content and assessment activities to create a personalized learning path for students, including **Aplia**. Lecturers can add or remove existing content within the learning path or add their own content in order to deliver a seamless student experience that aligns exactly with the way they teach their course.

ACKNOWLEDGEMENTS

We are indebted to many individuals for their ideas and assistance in preparing this and previous editions of the book. In particular, we would like to thank the following who have provided material for inclusion in the text and the book's accompanying digital support resources or who have commented on this and earlier editions of the book:

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In recognition for his contribution to accounting education and research, Drury was given a Lifetime Achievement Award by the British Accounting and Finance Association in 2009.

Colin's Flagship title *Management and Cost Accounting* was first published in 1985 and is now in its 11th edition. It established itself as one of the leading management accounting textbooks in EMEA. It is known, not just for its rigour and authority, but particularly for Colin's down-to-earth style that reflected his background as a practising accountant before his involvement in academia.



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PART ONE

INTRODUCTION TO MANAGEMENT AND COST ACCOUNTING

- 1 Introduction to management accounting**
- 2 An introduction to cost terms and concepts**

The objective of this section is to provide an introduction to management and cost accounting. In Chapter 1 we define accounting and distinguish between financial, management and cost accounting. This is followed by an examination of the role of management accounting in providing information to managers for decision-making, planning, control and performance measurement. We also consider the important changes that have taken place in the business environment. As you progress through the book you will learn how these changes have influenced management accounting systems. In Chapter 2 the basic cost terms and concepts that are used in the cost and management accounting literature are described. This terminology is essential to the study of management accounting. It is used in the further chapters of this book and in business practice.

1

INTRODUCTION TO MANAGEMENT ACCOUNTING

LEARNING OBJECTIVES After studying this chapter you should be able to:

- distinguish between management accounting and financial accounting
- identify and describe the elements involved in the decision-making, planning and control process
- justify the view that a major objective of commercial organizations is to broadly seek to maximize future profits
- explain the important changes in the business environment that have influenced management accounting practice
- outline and describe the key success factors that directly affect customer satisfaction
- identify and describe the functions of a cost and management accounting system.

There are many definitions of accounting, but the one that captures the theme of this book is the definition formulated by the American Accounting Association. It describes accounting as:

the process of identifying, measuring and communicating economic information to permit informed judgements and decisions by users of the information.

In other words, accounting is concerned with providing both financial and non-financial information that will help decision-makers to make good decisions. In order to understand accounting, you need to know something about the decision-making, planning and control process, and also to be aware of the various users of accounting information.

During the past two decades, many organizations in both the manufacturing and service sectors have faced dramatic changes in their business environment. Deregulation and extensive competition from international companies in domestic markets has resulted in a situation where most companies now operate in a highly competitive global market. At the same time there has been a significant reduction in product life cycles arising from technological innovations and the need to meet increasingly discriminatory customer demands. To succeed in today's highly competitive environment, companies have made customer satisfaction an overriding priority. They have also adopted new management

approaches and manufacturing companies have changed their manufacturing systems and invested in new technologies. These changes have had a significant influence on management accounting systems.

The aim of this first chapter is to give you the background knowledge that will enable you to achieve a more meaningful insight into the roles, benefits, issues and problems of cost and management accounting that are discussed in the book. We begin by looking at the users of accounting information and identifying their requirements. This is followed by a description of the decision-making process and the changing business environment. Finally, the different functions of management accounting are described.

THE USERS OF ACCOUNTING INFORMATION

Accounting is a language that communicates economic information to various parties (known as stakeholders) who have an interest in the organization. **Stakeholders** fall into several groups (e.g. managers, shareholders and potential investors, employees, suppliers and customers, creditors and the government) and each of these groups has its own requirements for information:

- Managers require information that will assist them in their decision-making and control activities; for example, information is needed on the estimated selling prices, costs, demand, competitive position and profitability of various products/ services that are provided by the organization.
- Shareholders require information on the value of their investment and the income that is derived from their shareholding. Likewise, potential investors are interested in their potential returns.
- Employees require information on the ability of the firm to meet wage demands and avoid redundancies, and its potential to provide continued employment.
- Creditors and the providers of loan capital require information on a firm's ability to meet its financial obligations.
- Government agencies such as the Central Statistical Office collect accounting information and require such information as the details of sales activity, profits, investments, stocks (i.e. inventories), dividends paid, the proportion of profits absorbed by taxation and so on. In addition, government taxation authorities require information on the amount of profits that are subject to taxation. All this information is important for determining policies to manage the economy.

The need to provide accounting information is not confined to business organizations. Non-profit-making organizations such as churches, charitable organizations, clubs and government units such as local authorities, also require accounting information for decision-making, and for reporting the results of their activities. For example, a tennis club will require information on the cost of undertaking its various activities so that a decision can be made as to the amount of the annual subscription that it will charge to its members. Similarly, municipal authorities, such as local government and public sector organizations, need information on the costs of undertaking specific activities so that decisions can be made as to which activities will be undertaken and the resources that must be raised to finance them.

As you can see, there are many different users of accounting information who require information for decision-making. The objective of accounting is to provide sufficient information to meet the needs of the various users at the lowest possible cost. Obviously, the benefit derived from using an information system for decision-making must be greater than the cost of operating the system.

The users of accounting information can be divided into two categories:

- 1 internal users within the organization, such as managers and other employees who need this information to operate their part of the business to best effect
- 2 external users such as shareholders, creditors and regulatory agencies, outside the organization.

From the above, it is possible to distinguish between two branches of accounting, which reflect the internal and external users of accounting information. **Management accounting** is concerned with the provision of information to people within the organization to help them make better decisions and improve the efficiency and effectiveness of existing operations, whereas **financial accounting** is concerned with the provision of information to external parties outside the organization, including the general public. Thus, management accounting could be called internal reporting and financial accounting could be called external reporting. This book concentrates on management accounting.

DIFFERENCES BETWEEN MANAGEMENT ACCOUNTING AND FINANCIAL ACCOUNTING

The major differences between these two branches of accounting are:

- *Legal requirements.* There is a statutory requirement for limited companies to produce annual financial accounts, regardless of whether or not management regards this information as useful. Management accounting, by contrast, is entirely optional and information should be produced only if it is considered that the benefits it offers management exceed the cost of collecting it.
- *Focus on individual parts or segments of the business.* Financial accounting reports describe the whole of the business, whereas management accounting focuses on parts of the organization; for example, the cost and profitability of products, services, departments, customers and activities.
- *Generally accepted accounting principles.* Financial accounting statements must be prepared to conform with the legal requirements and the generally accepted accounting principles established by the regulatory bodies such as the International Accounting Standards Board. These requirements are essential to ensure uniformity and consistency, which make intercompany and historical comparisons possible. Financial accounting data should be verifiable and objective. In contrast, management accountants are not required to adhere to generally accepted accounting principles when providing managerial information for internal purposes. Instead, the focus is on serving the management's needs and providing information that is useful to managers when they are carrying out their decision-making, planning and control functions. Indeed, it could be said that the best management accounting is that which is most useful to the manager, and this varies with the business size, sector, technology and the circumstances of the question or problem.

- *Time dimension.* Financial accounting reports what has happened in the past in an organization, it is historical; whereas management accounting is concerned with *future* information as well as past information. Decisions are concerned with *future* events and management therefore require details of expected *future* costs and revenues, which by definition are predictions and not known with certainty.
- *Report frequency and less emphasis on precision.* A detailed set of financial accounts is published annually and less detailed accounts are sometimes published semi-annually. Management usually requires information more quickly than this if it is to act on it. Managers are often more concerned with timeliness than precision. They prefer a good estimate now rather than a precise answer much later. Consequently, management accounting reports on various activities may be ad hoc investigations or be prepared at daily, weekly or monthly intervals.

THE DECISION-MAKING, PLANNING AND CONTROL PROCESS

Information produced by management accountants must be judged in the light of its ultimate effect on the outcome of decisions. It is therefore important to have an understanding of the *decision-making, planning and control process*. Figure 1.1 presents a diagram of the decision-making, planning and control process. The first four stages represent the decision-making and planning process. The final two stages represent the **control process**, which is the process of measuring and correcting actual performance to ensure the best alternatives are chosen and the plans for implementing them are carried out. We will now examine the stages in more detail.

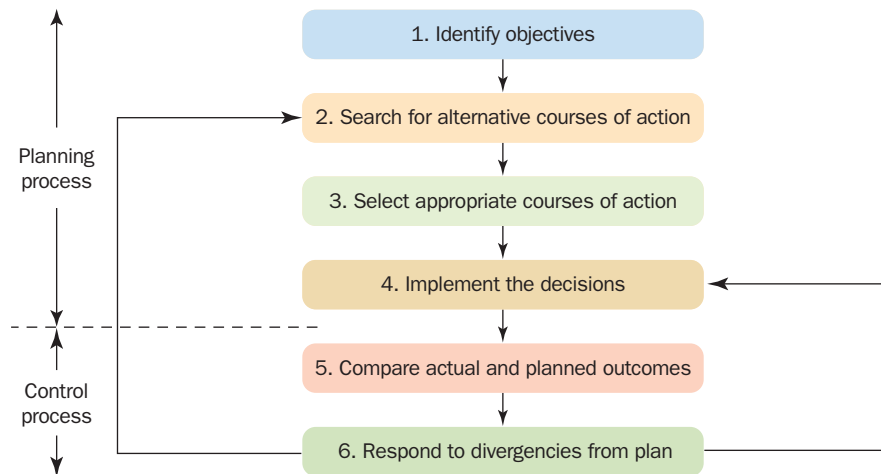


FIGURE 1.1

The decision-making, planning and control process

Identifying objectives

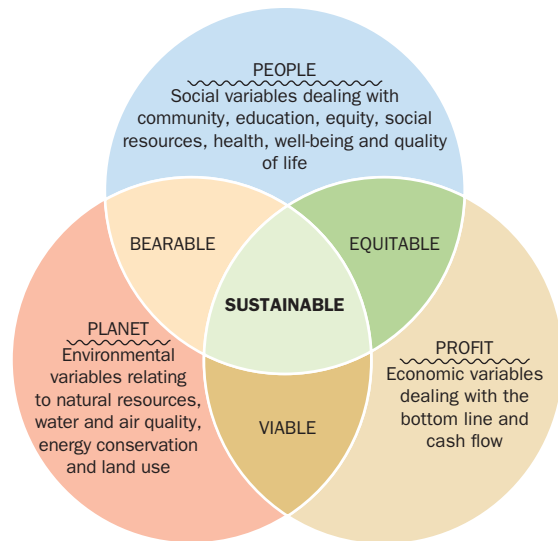
Before good decisions can be made there must be some guiding aim or direction that will enable the decision-makers to assess the desirability of choosing one course of action over another. Hence, the first stage in the decision-making process should be to specify the company's goals or organizational objectives, that is, what they are in business to achieve.

This is an area where there is considerable controversy. Economic theory traditionally assumes that firms seek to maximize profits for the owners of the firm or, more precisely, the maximization of shareholders' wealth. Some writers (e.g. Simon, 1959) believe that many managers are content to find a plan that provides satisfactory profits rather than to maximize profits. Clearly it is too simplistic to say that the only objective of a business firm is to maximize profits. Some managers seek to establish a power base and build an empire. Another common goal is security, and the removal of uncertainty regarding the future may override the pure profit motive. Organizations may also pursue more specific objectives, such as producing high-quality products or being the market leader within a particular market segment. We are also seeing an increasing interest in the responsibility of firms to a wider society at the present time: in other words responsibility to a wider stakeholding, and hence stakeholder capitalism and not just shareholder capitalism. This is demonstrated by calls for firms to publish a Triple Bottom Line of performance, covering social, environmental, and economic performance of profitability. It is only by addressing these three requirements that firms could be said to be 'sustainable' (see Figure 1.2). We shall discuss the implications for management accounting of these developments in Chapter 16. Nevertheless, the view adopted in this book is that, *broadly*, firms seek to maximize future profits. There are two reasons for us to concentrate on this objective:

- 1 It is unlikely that any other objective is as widely applicable in measuring the ability of the organization to survive in the future.
- 2 It is unlikely that maximizing future profits can be realized in practice, but by establishing the principles necessary to achieve this objective you will learn how accounting information can highlight how profits can be increased.

FIGURE 1.2

The interconnection of the elements of the Triple Bottom Line concept



The search for alternative courses of action

The second stage in the decision-making model is a search for a range of possible courses of action (or **strategies**) that might enable the objectives to be achieved. If the management of a company concentrates entirely on its present product range and markets, and market shares and profits are allowed to decline, there is a danger that the company will be unable to survive in the future. If the business is to survive, management must identify potential opportunities and threats in the current environment

and take specific steps now so that the organization will not be taken by surprise by future developments. In particular, the company should consider one or more of the following courses of action:

- 1 developing *new* products for sale in *existing* markets (product development)
- 2 developing *new* markets for *existing* products (market development)
- 3 developing *new* products for *new* markets (diversification).

The search for alternative courses of action involves the acquisition of information concerning future opportunities and environments; it is the most difficult and important stage of the decision-making process. We shall examine this search process in more detail in Chapter 9. Note that whilst the management accountant might provide information to support this judgement, it involves executives from all functions including marketing, manufacturing and service operations, R&D, IT, etc.

Select appropriate alternative courses of action

In order for managers to make an informed choice of action, data about the different alternatives must be gathered. For example, managers might ask to see projected figures on:

- the potential growth rates of the alternatives under consideration
- the market share the company is likely to achieve
- projected profits for each alternative.

The alternatives should be evaluated to identify which course of action best satisfies the objectives of an organization. The selection of the most advantageous alternative is central to the whole decision-making process and the provision of information that facilitates this choice is one of the major functions of management accounting. These aspects of management accounting are examined in Chapters 3–6.

Implement the decisions

Once the course of action has been selected, it should be implemented as part of the budgeting and long-term planning process. The **budget** is a financial plan for implementing the decisions that management has made. The budgets for all of the various decisions a company takes are expressed in terms of cash inflows and outflows, and sales revenues and expenses. These budgets are initially prepared at the departmental/responsibility centre level (i.e. a unit or department within an organization for whose performance a manager is held responsible) and merged together into a single unifying statement for the organization as a whole that specifies the organization's expectations for future periods. This statement is known as a **master budget** and consists of budgeted profit and cash flow statements. The budgeting process communicates to everyone in the organization the part that they are expected to play in implementing management's decisions. We shall examine the budgeting process in Chapter 9.

Comparing actual and planned outcomes and responding to divergencies from plan

The final stages in the process outlined in Figure 1.1 involve comparing actual and planned outcomes and responding to divergencies from plan. The managerial function of **control** consists of the measurement, reporting and subsequent correction of performance in an attempt to ensure that the firm's objectives and plans are achieved.

Exploring the Variety of Random Documents with Different Content

CHAPTEE XIX FIRE »< W E do not know how man first procured fire. Did he take advantage of some blaze started by a thunderbolt, or did he kindle his first firebrand in the crater of a volcano? No one can tell. Whatever may have been its source, man has enjoyed the use of fire from the earliest times ; but as the means of relighting it if it went out were very imperfect or even lacking altogether, the utmost care was taken to maintain it, and a few live coals were always kept over from one day to the next. * ^ So calamitous would have been the simultaneous extinction of the fires in all the dwellings that, in order to guard against such a disaster, the priesthood took fire under its special protection. In ancient Rome, many centuries ago, an order of priestesses called Vestals was charged with the guarding of the sacred fire night and day. The unfortunate one who let it go out was punished with horrible torture: she was buried alive!" **Did they really bury her alive for letting the fire go outr' asked Jules. **Yes, my boy. This terrible punishment inflicted on the keepers of the fire shows you the importance they attached to keeping at least one hearth alight so that others could be kindled from it." * * One of our matches that we buy at a cent a hun104

FIRE 105 dred/' said Claire, ^Svould have saved the life of the careless Vestal." **Yes, to abolish those barbarous severities it needed only a match, a thing which unfortunately was at that time unknown. *^Many centuries passed before it was discovered how to procure fire easily. In my young days, when I was about your age, keeping coals alive to be used for relighting the fire next day was still the rule in the country. In the evening before the family went to bed, the embers were carefully covered with hot ashes to prevent their burning out and to keep them alive. If, despite this precaution, the hearth was cold next morning, some one had to hasten to the nearest neighbor's to borrow some fire, that is to say a few live coals, which were carried home in an old wooden shoe to keep the wind from blowing them away. ' ' ^^But I should think the old wooden shoe would have caught fire," said Emile. ^^No, for care was taken to put a layer of ashes in first. I have told you how some children would put a few ashes in the hollow of their hand, and on the ashes lay live coals. They carried fire thus just as you would carry a handful of sugar-plums. *^The layer of ashes arrested the heat of the embers and prevented its reaching the hand. Remember what I have already told you about the poor conducting power of ashes, their refusal to transmit heat, a characteristic they have in common with all powder}^ substances. The little fire-borrowers knew that well enough,"

106 THE SECRET OF EVERYDAY THINGS ' ' But who taught them to do it that way ! ' ' asked Emile. '^The great teacher of all things, necessity. Caught without shovel or wooden shoe, some one of them, knowing this peculiarity of ashes in arresting heat, made use of the ingenious device I have described, and his example was sooner or later followed by others. ^^Fire-producing devices are, as a rule, based on the principle that heat is generated by friction. We all know that we can warm our hands by rubbing them against each other. ' ' ^'That's what T alwaj^s do in winter when my hands are frozen from making snowballs," said Jules. *^That is one of the oldest illustrations of the effect of friction, and I will add another. Hold this round-headed metal button by the shank and rub it briskly on the wood of the table; it will become warm enough to produce a decided feeling on the skin." Claire took the button, rubbed it on the wood of the table, and then applied it quickly to her hand, uttering a little cry of surprise and even of pain as she did so. ' ' Oh, how hot the button is. Uncle ! ' ' she exclaimed. ^ ' If I had rubbed any longer I should have scorched my hand. ' ' ^ ^ It is by similar means that certain savage tribes procured and still procure fire. They twirl very rapidly between their hands a slender stick of hard wood with its pointed end inserted in a cavity hoi

FIRE 107 lowed in soft and very inflammable wood. If the friction is brisk enough and the operation properly carried out, the soft wood catches fire. This process, I admit, would fail of success in our hands for lack of skill. '^ *^For my part," said Marie, "if I had nothing but a pointed stick and a piece of wood with a hole in it for lighting a fire, I should despair of ever managing it. ' ' "I should not even try it," Claire confessed, "it seems so difficult, although the button that I rubbed came near burning me." "A\Tiat would be impossible for us is mere play for the natives of Australia. The operator sits on the ground, holding between his feet the piece of wood with the little hole, and twirling the pointed stick rapidly between his hands he soon obtains a spark with which he kindles a few dry leaves. "Even in our o\m country you may see, in any wood-turner's shop, this friction process employed successfully. To obtain the brown ornamental lines on certain objects turned in a lathe, the operator presses with some force the point of a bit of wood on the piece in rapid rotation. The line thus impressed by friction begins to smoke in a few moments, and soon becomes carbonized. "I pass on to other methods of producing fire. Iron and steel, especially the latter, if rubbed against a very hard stone give out sparks made by tiny scales of metal that become detached and are sufficiently heated to turn red and burn in the air. Thus the scissors-grinder 's revolving stone, although

108 THE SECRET OF EVERYDAY THINGS constantly moistened with water, throws out a shower of sparks under the steel knife or other tool that is being sharpened. In like manner the cobblestone struck by the horse's iron shoe emits sudden and brilliant flashes. ^ ^ The common flint-and-steel apparatus acts in the same way. It consists of a piece of steel that is struck against the edge of a very hard stone called silex or flint. Particles of steel are detached from the metal and, made red-hot by the friction, set fire to the tinder. This latter is a very combustible substance obtained by cutting a large mushroom into thin slices and drying them, the mushroom being of the kind known as touchwood, which grows on tree trunks. "

CHAPTER XX MATCHES * < AS tinder burns without flame, the glowing spark jlv obtained with flint and steel before the invention of our matches did not suffice for obtaining fire ; we had to have recourse to sulphur, which possesses the invaluable property of bursting into flame at the mere touch of a red-hot substance. ^ * Sulphur is so well known to you as to render any description of it here unnecessary. It is found especially in the neighborhood of volcanoes, where it occurs in the soil, sometimes in masses free from all admixture, sometimes in mingled masses of sulphur and earth or stone. Man's work consists merely in purifying the sulphur by melting it as it comes from the mine. **In the olden time matches were made of pieces of hemp dipped at one end into sulphur. They were lighted by having the sulphur-tipped end touched either to a live coal that was kept glowing under the ashes, or to a bit of tinder previously kindled by flint and steel. Thus you see the mere lighting of a lamp was a process not devoid of complications. First the flint and steel must be struck together, at the risk of bruising one^s fingers by an awkw^ard movement in the dark; then, when the tinder had taken fire after many attempts which often exhausted the 109

110 THE SECRET OF EVERYDAY THINGS patience, it was necessary to apply the sulphur match in order to obtain a flame." ^*Our matches of to-day are much to be preferred," remarked Claire. *^A11 you have to do is to strike them against the box cover or against the wall or a piece of wood, no matter where, and the thing is done: the fire burns." *^This inestimable benefit of being able to obtain fire without difficulty and on the instant we owe to phosphorus, a substance discovered, as I have already told you,^ by a learned investigator named Brandt, who lived in Hamburg two hundred years ago. In attempting the impossible transformation of baser metals into gold, he hit upon an elementary substance until then unknown, and thus gave us the self-igniting sulphur match with its tip of phosphorus. ^ ^ ' If you examine one of our common matches you will see that the inflammable end is coated, first with sulphur, and then, over this, with phosphorus, the latter being colored with a red, blue, or brown powder, according to the maker's fancy. Phosphorus by itself is yellowish and translucent like wax. Its name means light-bearer. When it is rubbed gently between the fingers in a dark place, the fingers are seen to be covered with a pale light. At the same time a smell like that of garlic is detected; it is the odor of phosphorus. So inflammable is this substance that it takes fire when heated only a very little or when rubbed against any hard 1 See "Field, Forest, and Farm."

MATCHES 111 surface. Hence its use in the manufacture of friction-matches. ^' These are little sticks of wood — willow, poplar, or spruce — wrought with the help of steel plates pierced with holes ha\TJig sharp cutting edges through which the wood is forced by powerful pressure. Then these little sticks, held in position by frames made for the purpose, are first dipped at one end into melted sulphur. Over this first coating, which is designed to feed the flame and give it sufficient intensity to ignite the wood, must be laid a second that will take fire by friction ; and this latter coating is composed chiefly of phosphorus. On a marble table is spread a semi-fluid paste made of phosphorus, glue, very fine sand, and some coloring matter. The matches, still held in position by the frames just referred to, have their sulphur tips touched for an instant to this inflammable paste, and are then placed in an oven where the paste is allowed to dry. Friction, aided by the fine sand incorporated in the paste, develops enough heat to ignite the phosphorus; this in turn sets the sulphur on fire, and from the sulphur the flame spreads to the wood. ^'Phosphorus is a deadly poison, and therefore matches must be handled with care, this precaution extending even to the empty boxes that have held them. Contact with our food might entail serious consequences. Nevertheless this fearful substance is found in all animal bodies. It is present in the urine, whence Brandt was the first to extract it; it occurs in meat, in milk, and above all in bones.

112 THE SECRET OF EVERYDAY THINGS Plants also, especially cereals, contain it, and hence it enters into the composition of flour and of bread. ' ' *^What!" exclaimed Claire, ^^a substance so frightful, a poison so violent, is found in milk, ^meat, and bread 1 ' ' ^' Don't be alarmed, '^ her uncle reassured her. **We run no risk whatever of being poisoned by drinking a glass of milk or eating meat and bread. The phosphorus there present does not occur by itself, but combined with other substances which deprive it entirely of all poisonous attributes and render it useful, in fact necessary, to the strength of the body. It is to be feared as a poison only in the condition in which it is found in matches. I should add in conclusion that the method adopted by Brandt for obtaining phosphorus — namely, from urine — has long since been abandoned. At the present time it is extracted from the bones of animals." *^Then it is bones that furnish us with phosphorus?" said Jules. ^^Yes, bones are by an ingenious device made to yield us phosphorus and, consequently, light and heat

CHAPTER XXI WOOD AND CHARCOAL OF wood used for fuel it is customary to distinguish two kinds, hard and soft. At the head of the former class stand the different species of oak, notably the common oak scattered all over France, and the evergreen or holm oak peculiar to the south. This last is called evergreen because it does not shed its foliage in winter, but continues green the year through. Among the soft woods are the poplar, willow, plane-tree, and pine. ^The way in which these two kinds of wood burn is quite different in the two instances. Soft wood, suitably dried, takes fire readily and gives much flame with a heat that is quick but of short duration. It is convenient for use in the kitchen, where it is often necessary to obtain a prompt and intense heat, for example in roasting fowl on the spit and in cooking with the frying-pan. Furthermore, soft wood is very useful for kindling other and less combustible fuel, such as hard wood, coal, and charcoal. But for use in open fireplaces, when it is desired to keep a fire going all day long, soft wood is by no means economical, because it bums up so quickly. The best fuel in this case is oak, which bums slowly and yields a large, compact mass of coals that retain their heat 113

114 THE SECRET OF EVERYDAY THINGS for hours at a time, especially if care is taken to cover them partly with ashes. '^ 'I have noticed the difference you speak of," said Marie. ^^ Willow and poplar burn to ashes in a few minutes, leaving hardly any coals; but oak gives a fire that lasts and at the same time leaves a mass of glowing coals. '^ ^^If we had to keep up a fire with dry twigs and willow splinters," remarked Claire, ^^we should be kept busy all day throwing on wood, whereas three or four sticks of oak last a long time." Emile here interposed with a question. *^How is charcoal made, ' ' he asked, ^ ^ such as is used for cooking!" '^Charcoal is made from wood," was the reply. ^'Its superiority to wood is that it bums almost without smoke and without flame, a very valuable quality where cleanliness is desired, as it is in our kitchens. More than that, charcoal yields a heat that is equable and lasting, thus dispensing with the need of careful watching. The best charcoal is obtained from the best wood, that is to say from oak, especially evergreen oak. I will now describe its mode of manufacture as followed by charcoal-burners in the heart of a forest. ^^Upon a plot of ground beaten hard and level there is first built a sort of chimney made of logs planted vertically in the soil, and around this chimney the wood destined to be converted into charcoal is piled in tiers, one on top of another, but with openings left at the base for admitting air. The whole is covered with a layer of earth and sod, leaving ex

WOOD AND CHARCOAL 115 posed only the central chimney and the air-holes at the base. Finally, the mass is set on fire by means of dry brushwood. " ^^I should think, '^ said Jules, ^'that the whole pile would burn up and leave nothing but ashes, a dead loss to all concerned. '^ *^By no means," replied Uncle Paul. ^^ Since air can reach the burning mass only with difficulty, combustion is slow and the wood is but half consumed. Besides, if the fire should burn too briskly the attendants would make haste to stop up with sod some or, if necessary, all of the vents at the base of the pile. As soon as the pile is thought' to be one mass of glowing coals, the fire is smothered with earth and the structure is left to cool off. When this process is complete the work of demolition is undertaken, and in place of wood in its primitive state there is found nothing but charcoal. Some few fragments there may be that are not thoroughly charred, and they are recognized by their reddish color. They are the half-burnt pieces we find now and then in our charcoal." ^'I know them," said Claire, ^Hhey make such a disagreeable smoke; and I always take them out of the stove as quickly as I can and throw them into the fireplace." ' ' That is right, ' ' returned Uncle Paul. ' ' And now let us direct our attention to another kind of coal, the coal that is dug out of the earth and that comes to us from the coal-mines. Coal of this sort is of vegetable origin, no less than the charcoal whose mode of manufacture in the heart of the forest you

116 THE SECRET OF EVERYDAY THINGS now understand.
But charcoal-burners do not make this other coal ; it is found all
made in the bowels of the earth, at great depths below the surface.
'^ *'But how,'^ asked Claire, ^'can coal from deep down in the
earth come from vegetable matter growing only on the surface 1 ' '
**To explain that to you in full is out of the question, because your
knowledge is still too elementary; but I can at least give you some
idea of the natural processes involved. *^Let us suppose the
existence of great forests of luxuriant growth, forests that man can
never penetrate with his instruments of destruction. The trees fall
under the weight of years and go to decay at the foot of other and
younger trees, forming at last a layer of matter half carbonized by
the action of the elements. One generation of trees succeeds
another, and the layer grows thicker, so that after centuries it attains
the thickness of a meter or more. Imagine now a succession of
violent earthquakes which break up the surface of the earth, pushing
up mountains where before there have been plains, and making
plains where there have been mountains. Imagine, further, that as a
result of these changes of level the sea is displaced and forced to
forsake, wholly or partly, its old bed for a new one; conceive of this
new sea as covering the shattered remains of old forests with mud
and sand that eventually become hardened and converted into thick
beds of rock ; and, finally, picture to yourselves the sea as at last, in
consequence of still further upheavals of the earth's

WOOD AND CHARCOAL 117 surface, forsaking the new bed it had found for itself and seeking still another, leaving behind it a continent of dry land. Thus you will have all the essential facts that you require in order to understand the presence of coal in the interior of the earth." ^^But those frightful upheavals that you speak of," put in Jules, ^' those great changes that make continents of seas and seas of continents — have they ever really taken place?" ^^A science called geology," replied Uncle Paul, ^^ teaches us that these events actually occurred as I have described them, but so long ago that man was not yet in existence. ^ ' There was a time, for example, when this corner of the globe that bears to-day the fair name of France was composed merely of a few small islands lost in a vast ocean. On these islets, which were covered with lakes and volcanoes, there flourished a luxuriant vegetation, the like of which is no longer anywhere to be found except perhaps in the depths of some tropical jungle. The very regions where now grow beech trees and oaks used to bear immense ferns, each balancing at the top of its tall stem a graceful cluster of enormous leaves. These fern trees constituted the greater part of somber, damp forests which were never enlivened by the song of birds and never heard the step of quadruped ; for as yet the dry land was without inhabitants. The sea alone maintained beneath its billows a population of monsters, half fish, half reptile in form, their flanks clothed in an armor of glittering scales. The re

118 THE SECRET OF EVERYDAY THINGS mains of that ancient vegetation, buried in the depths of the earth by some stupendous cataclysm, have become the coal-beds of to-day in which are still discerned the admirably preserved outlines of leaf and stalk. ^'

CHAPTER XXII COAL AND COAL-GAS

120 THE SECRET OF EVERYDAY THINGS should very much like to hear more about them." *^Let us talk a little more, then, about coal. But what could I select humbler in appearance and less worthy of your attention than that black stone! Nevertheless there are some most astonishing things to be said about it. First of all, coal — black, dirty, with no claim to distinction in its aspect — is own brother to the diamond, the sumptuous gem that for brilliance has no equal in all the world. The diamond is made of carbon, and so is coal — the very same substance in both. ' ' ^ * The diamond made of carbon ? ' ' cried Claire, incredulously. ^^Yes, my child, of carbon and nothing else." <

COAL AND COAL-GAS 121 found, in the cleavage between two layers, distinct traces of carbonized vegetable matter having perfectly recognizable outlines. Certain coal-beds are formed entirely of leaves heaped up and pressed together into a solid block, and still preserving, despite their conversion into coal, all the details of their delicate structure. These relics of a plant life as old as the world, wonderful archives which tell us the earth's history, are so well preserv[^]ed that they enable us to recognize the carbonized plants with the same certainty we feel in recognizing living plants. Yesterday, while our winter supply of coal was being put in, I chanced to notice in the bin some of those venerable relics I have just been speaking about, and I put them aside to show to you. Here they are. " ^[^]Oh, what beautiful leaves!" exclaimed Marie. '[^]How nicely they are attached to the black surface underneath! One would say they had been cut out of very thin sheets of coal." She stood lost in thought before these remains of forests so extremely old as to antedate all animal life. *[^]When the plant life was flourishing which you see represented here," went on Uncle Paul, ^^Hhe earth was covered with a vigorous growth of vegetation unexampled in our o[^][^][^]I time. This vegetation, buried far underground by changes in the earth's surface, and carbonized in the course of a long series of, centuries, has become transformed into enormous masses of coal which constitute the soul, so to speak, of modern industry. For it is coal that moves the railway locomotive, with its line of heavy cars ; it is coal that feeds the furnaces of factories; it is coal

12£ THE SECRET OF EVERYDAY THINGS that enables the steamboat to brave wind and storm ; and it is coal that makes it possible for us to work the various metals and manufacture our tools and instruments, our cloth and pottery, our glassware and all the infinite variety of objects necessary to our welfare. Are you not filled with wonder, my children, as I am, that long before man's appearance upon earth everything was prepared for his reception and for providing him with the things essential to his future industry, his activity, his intelligence! Are you not impressed by this vegetation of prehistoric times which stored up in the bowels of the earth those precious deposits of coal that to-day are brought to light and made to move our machines and become one of the most active agents of civilization?" ^^From now on," replied Marie, '*' whenever I put a shovelful of coal on to the fire, I shall think of that ancient plant life which gave us this fuel. ' ' ^'Nor is the whole story of coal told yet," Uncle Paul went on. ^^ Besides heat, coal gives us light. Cities are illuminated by street lamps which bum no oil and have no wick, but emit a simple jet of gas which, on being ignited, produces a magnificent white flame. ^ This gas is obtained by heating coal red-hot in great air-tight ovens. Pipes laid under ground conduct the gas from the gas-works to all parts of the city and distribute it to the street lamps. At nightfall the burner is opened and the gas flows, tak1 Only older readers will recall this method of street-lighting, which has long since been superseded by electric lamps of various kinds, — Translator,

COAL AND COAL-GAS 123 ing fire at a little hand-lantern with exposed wick, whereupon the flame bursts forth. **What remains in the ovens after the manufacture of illuminating gas is a modification of coal known as coke, an iron-gray substance with a dull metallic luster. Coke develops much more heat than the best wood-charcoal, but is difficult of combustion and in order to burn well must be heaped up in considerable quantity and have a good draft. For domestic heating it is used in stoves and, still oftener, in grates. It is superior to coal in giving forth no smoke, thus being cleaner. ^* Together with gas there is produced in the ovens in which coal is heated a black and sticky substance called coal-tar. From this horrible pitch, which one cannot touch without soiling one's hands, modern invention knows how to extract something in the highest degree fresh and beautiful and fair to look upon. As we have seen, the splendid colors of our silks and cottons, the rich and varied tints of our ribbons — all these we owe to dyestuffs obtained from coal-tar. Common coal, therefore, far from impressive though it is in appearance, is linked with the most dazzling splendors this world can produce: on the one hand with the diamond, with which it is one in essence, and on the other with the flowers of the field, whose delicate coloring it imitates and even surpasses/^

CHAPTER XXIII COMBUSTION ^ ' T ET us light a shovelful of charcoal in the kitchen i J stove. The charcoal catches fire, turns red, and is consumed, while at the same time producing heat. Before many minutes there is nothing left but a handful of ashes weighing but a trifle compared with the quantity of charcoal burned. What, then, has become of the charcoal? *' **It has been consumed," answered Jules; ^*it is burnt up.'* ^^ Agreed. But being consumed — does that mean being reduced to nothing? Does charcoal, when once it has been burned, become nothing at all, absolutely nothing ? ' ' *^It has turned to ashes," Jules replied. ^*You haven't hit it yet, for the ashes left after combustion amount to very little compared with the quantity of charcoal consumed. ' ' **Your question, dear Uncle," Marie here interposed, "puzzles not only Jules, but me too, very much indeed. If there -is n't any more than a handful of ashes left after the charcoal is burnt up, I should say the rest has been destroyed. ' ' "If that is your opinion I would have you know that in this world nothing is 'ever entirely destroyed, not a particle of matter ever becomes nothing after 124

COMBUSTION 1⁵ having been something. Try to annihilate a grain of sand. You can crush it, convert it into impalpable powder; but reduce it to nothing — never. Nor could the most skilful of men, men equipped with more varied and more powerful appliances than ours, succeed any better. In defiance of every exertion of ingenuity or violence the grain of sand will still continue to exist in some form or other. Annihilation and accident, two big words that we use at every turn, really do not mean anything. Ever[}]^thing obeys laws : everything persists, is indestructible. The shape, aspect, appearance, changes; the underlying substance remains the same. "So the charcoal that is burned is not annihilated. True, it is no longer in the stove ; but it is in the air, dissipated and invisible. When you put a lump of sugar into water the sugar melts, is disseminated throughout the liquid, and from that time ceases to be visible even to the keenest scrutiny. But that sugar has not ceased to exist. The proof is that it communicates to the water a new property, a sweet taste. Furthermore, nothing stands in the way of its ultimate reappearance in its original form. All we have to do is to expose the sweetened water to the sun in a saucer; the water will disappear in vapor and the sugar remain. "Charcoal behaves in like manner. In burning it is dissipated in the air and becomes invisible. This dissipation is called combustion. What do we do when we wish to make the fire burn faster? With the bellows we blow air on the fuel. With each puff the fire revives and burns brighter. The live coals,

1^6 THE SECRET OF EVERYDAY THINGS at first dull red, become bright red and then whitehot. Air breathes new life into the bosom of the burning mass. If we wish, on the other hand, to prevent a too rapid consumption of fuel, what do we do! We cover the fire with ashes, thus keeping out the air. Under this layer of ashes the live coals retain their heat and remain red for a long time without being consumed. Thus it is that a fire in a grate is maintained only by the constant admission of air, which makes the coal burn ; and the faster it burns, the greater the amount of heat given off. ' ' * ^ Then that must be why the stove gets so hot when it roars," remarked Claire. *'Air is let in between the bars of the grate and then goes roaring through the red-hot coals. But if the air is prevented from circulating by closing the door of the ash-pit, the heat subsides at once." ^^When the air is impregnated mth carbon it acquires new properties, just as water does on becoming charged with salt or sugar. This new element is an injurious substance, a harmful gas, all the more to be feared because it does not reveal its presence, having neither smell nor color. We do not take note of it any more than we do of ordinary air. ^'But let any one breathe this formidable gas, and immediately the brain becomes clouded, torpor supervenes, strength fails, and unless help arrives death soon follows. You have all heard of unfortunate persons who inadvertently — sometimes, alas! designedly — have met death in a closed room by lighting a brazier. The fact that the air becomes impregnated with the dissipated carbon from the

COMBUSTION in burning charcoal explains these lamentable accidents. Inhaled even in a small quantity, this deadly gas induces first a violent headache and a general sense of discomfort, then loss of feeling, vertigo, nausea, and extreme weakness. If this state continues even a very little while, life itself is endangered. ^ * You see to what a risk charcoal exposes us when the products of its combustion do not escape outside through a chimney, but spread freely indoors, especially if the room is small and tightly closed. Under these conditions you cannot be too distrustful of a brazier. Whether burning brightly or half extinguished, whether covered with ashes or not, these embers exhale a deadly gas which does not announce its presence by any sign that we can recognize, but, like a traitor, always takes us by surprise. Death may occur even before danger is suspected. ** Again, it is very imprudent to close the damper of a bedroom stove for the sake of maintaining a moderate heat during the night. The stovepipe being closed by the damper, there is no longer any outlet for the products of combustion, which are sent out into the room and asphyxiate the sleepers, so that they pass from life to death without even waking up. ^ "If the apartment is small and without openings for changing the air, a simple foot-warmer is enough to cause a headache and even lead to more serious results. ' ' 1 With proper ventilation, as the author might have added, this danger is greatly lessened. — Translator.

IM THE SECRET OF EVERYDAY THINGB ^^Now I understand/' said Marie, ^Hhe headaches I sometimes have in winter when I am sewing in my little room, all shut up with a foot-warmer under my feet. It was the burning charcoal that gave me those headaches. That is a good thing to know, and I will be careful in future/' *^Be just as careful with charcoal when you are ironing. Keep the heater for the irons under the chimney or in a well-ventilated place, so that the dangerous exhalations from the embers may be carried out into the open air. Those who do ironing often complain of an uncomfortable feeling which they attribute to the smell of the iron, whereas it is due to the deleterious gas given off by the burning charcoal. It can be avoided by keeping the heaters under a chimney or in a current of air that drives away the injurious gas."

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