



## PREFACE

Nearly all engineering problems involve considerations and comparisons of cost. Arthur M. Wellington's classic remark made nearly fifty years ago that engineering was the art of doing well for one dollar what any bungler could do for two dollars, was his striking way of emphasizing this fact. In most cases the costs which are to be compared are not immediate costs, but rather costs in the long run.

The recent survey by the Society for the Promotion of Engineering Education brought out clearly the fact that among engineering graduates there is a general feeling that the most serious omission in their technical education was the failure to emphasize the economic aspects of engineering. In this connection, what the engineering student needs most of all is a point of view—the point of view that ultimate economy is a problem with which the engineer must be concerned. This point of view involves the realization that quite as definite a body of principles governs the economic aspects of an engineering decision as governs its physical aspects. The importance of engineering economy is likely to be more effectively emphasized, and the principles of comparison more likely to be covered with less duplication of effort, if these principles are presented in a separate course. This book is a text for such a purpose.

So far as possible, principles of cost comparison have been illustrated by a discussion of particular cases rather than expressed in terms of mathematical formulas. Actually, most problems in economy are solved as problems in arithmetic rather than algebra. Moreover, a highly mathematical discussion of problems of economy has two equally bad effects on the student. By obscuring fundamentally simple arithmeti-

cal relationships, it makes the mathematics of economy seem to be too hard, and by failing to give weight to non-quantitative judgment factors, and to the difficulties of finding costs, it makes the securing of correct decisions on matters of economy seem to be too easy.

Illustrative cases and problems which have been freely used are restricted by the desirability of having the book suitable for use by diversified groups of engineering students as early as the third year of their course, and an endeavor has been made to select illustrative matter that would be adapted to and readily understood by students from any branch of engineering.

Many engineering curricula now include courses in general economics and accounting. Partly for this reason, and partly because the unity of the book seemed to require consideration of each factor in relation to problems of economy, material has been avoided which would duplicate these courses. No attempt has been made to present useful cost information in any field of engineering. While the costs in some of the instances are taken from actual situations, in many other cases the actual facts have been oversimplified, or the costs have been arbitrarily assumed as applicable to typical situations. This plan has been adopted better to illustrate particular principles of economy. Emphasis has been placed upon fundamental principles rather than upon facts.

Although this book has been written primarily for students of engineering, it will be found useful by practicing engineers and industrialists. Despite the wealth of literature dealing with shop management, and business administration, systematic treatises on problems of economy are few. Yet such problems are being dealt with daily by engineers, production executives, purchasing agents, salesmen of technical products, controllers and accountants.

Acknowledgment is due to many engineers, economists, and educators, too numerous to mention individually, who generously gave their time to discussion of the subject of the

book, and whose suggestions of ideas and illustrations have been invaluable. Particular acknowledgment is due to General R. I. Rees of the American Telephone and Telegraph Company and to H. K. Fairbank of the United States Bureau of Public Roads for assistance in making contacts which resulted in the collection of much valuable material. Professor Eric Therkelsen and Professor W. F. Brewer of Montana State College, Dean Theodore J. Hoover of Stanford University, and Professor R. E. Chaddock of Columbia University have made helpful suggestions regarding parts of the manuscript. Professor J. C. L. Fish of Stanford University, both through his pioneer work in this field and through his sponsorship of the "Clearing House of Engineering Economics," has been indirectly responsible for many of the ideas contained in the following pages. Finally, acknowledgment must be made to Dean Earle B. Norris, now of Virginia Polytechnic Institute, without whose encouragement and guidance, over a number of years of teaching the subject, this book would not have been written.

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Palo Alto, California,

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# PRINCIPLES OF ENGINEERING ECONOMY

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## CHAPTER 1

### WHAT IS ECONOMY?

Economy, says one of the definitions in Webster's *New International Dictionary*, is management without loss or waste. It should be distinguished from parsimony, which means stinginess or too extreme frugality.

For the purpose of this book, economy is getting the most for your money in the long run. A somewhat more elegant definition is, securing the highest possible ratio of utility to cost.

The central problem discussed in this book is how we may judge whether any proposed course of action in an engineering enterprise will prove to be economical in the long run as compared to other possible alternatives. An economy study involves a comparison of costs and revenues involved in some proposed plan of action, either with costs and revenues involved in some alternative plan or with some standard of comparison.

**Economy in Everyday Life.**—Of course, economy is not exclusively a problem for the engineer. All of us are confronted daily with problems of deciding between alternative possible expenditures, and we usually try to make our decisions on the basis of securing the most satisfaction for our money in the long run. The universal nature of this problem of choice is well expressed by Stuart Chase and F. J. Schlink as follows:<sup>1</sup> "Why do you buy one make of automobile rather than another? Why do you draw up beside a filling station pump which is painted red rather than one which is painted yellow? Why do you buy the tooth paste you are using—

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<sup>1</sup> In the opening paragraph of *Your Money's Worth*.

what do you know about its relative merit compared with other tooth pastes—do you know if it has, beyond a pleasant taste, any merit at all? Is this cake of soap really going to give you a school girl complexion? How can you tell what type of electric refrigerator is technically the best within the range of what you can afford to pay; or oil heater, or vacuum cleaner, or electric washer, or radio set? Do you know what kind of paint or varnish you ought to have for the floors, the studio walls, the picket fence, the kitchen shelves? How many washings will those shirts survive; how many ball games those stockings for Junior; how many shaves that safety-razor blade?"

As this paragraph suggests, a great deal of the consumer's difficulty in judging real economy comes from a lack of any precise knowledge regarding the quality of the results obtainable from any alternative expenditures. Thus, in order intelligently to choose between a fifteen-dollar and a six-dollar pair of shoes, we ought to know how much the expensive pair may be expected to outlast the cheaper one. Possibly, the life of the expensive pair may be extended by a maintenance expenditure for new soles and heels while this would not be economical for the cheaper pair. If so, such information would be pertinent to a comparison of the economy of the two pairs.

Actually, even if we had this information, so that we could really determine which pair would cost the least in the long run, we should probably be influenced also by some other factors in making our choice. Personal taste, pride of ownership, the availability of our funds, might all enter into the decision. Real economy—in the sense of the greatest satisfaction per unit of expenditure—depends to a great extent on the point of view of the purchaser in matters of personal expenditure.

**Engineering Economy.**—Engineers' problems of economy are considerably less subjective than problems of personal



economy. Engineers are generally employed by commercial enterprises and are concerned with the design and selection of production equipment and with the planning of production processes for commercial organizations. The difference between making all decisions on careful analysis of the costs involved and the alternative of making all decisions on "hunches" or guesswork or unsupported opinion may be the difference between the commercial success or failure of an enterprise. The question, "Will it pay?" is an ever-present one in engineering decisions and the business manager must rely on the engineer's advice as to the financial effect of technical alternatives. This is true whether the engineer's activities relate to original construction, operation, or expansion.

**Analyzing the Question "Will It Pay?"**—This question, "Will it pay?" which must always be present in any engineering decision, may be broken down into several subsidiary questions.

General John J. Carty, as chief engineer of the New York Telephone Company, had three such questions which he applied to every engineering proposal which came before him for review:

1. Why do this at all?
2. Why do it now?
3. Why do it this way?

Why do this at all? Will a proposed new enterprise be profitable? Shall an existing enterprise be expanded? Shall existing operating procedures be modified?

Why do it now? Are market conditions favorable to a present development? Shall we build now with excess capacity in advance of demand, or with only sufficient capacity to satisfy the demand immediately in prospect? Are interest rates and business conditions favorable to a present development?

Why do it this way? This choice between alternative ways of doing the same thing is common to all types of engineering activity.