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THE ANALYSTS' BOOKSHELF

PHILIP M. MORSE AND GEORGE E. KIMBALL, *Methods of Operations Research*, The Technology Press, M.I.T., and John Wiley & Sons, Inc., New York, 1951, 158 pp., $4.00.

THE JOURNAL needs livening up a bit; all is too well, too placid, too complacent. There is nothing like a little good-humored controversy to clarify ideas, and with the bible of the SOCIETY in my clutches I have a not-to-be denied opportunity to play court jester.

Surely all of us have read the book by now so I need only recall that the first chapter is at some pains to make operations analysis not merely respectable but a branch of science; the second introduces probability and statistics; the next five present numerous examples of operations analysis; the final one contains a general discussion of the proper organization and behavior of operations analysis. It is an excellent report of operations analysis as carried out by the Navy's Operations Research Group during the last war.

The first sentence is the widely quoted definition: *Operational research is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control.* Now I would not breathe a word of this to outsiders but just among ourselves we will certainly have done a fine day's work when we sell that definition to the chairmen of the boards.

The definition states that our labors constitute *a scientific method* (there is more than one?), and the authors write "this implies recognized and organized activity amenable to application to a variety of problems and capable of being taught." I see no methodology which is generally applicable to a variety of problems; in fact I see no procedural methodology at all. I see a collection of problems to which are sometimes fitted simple models. The models strike me as useful only for almost identical problems. Apparently it is something else that forms the methodology and structure of this science. Is it the fitting of models? Physicists have been doing this sort of thing for lo these many years and are doubtless full of ideas and prescriptions for going about it. The book is not full of such ideas. It discusses particular models associated with particular problems in a very sensible way, but beyond a few more or less obvious general instructions there is not presented any comprehensive methodology. Judging from the contents of the book, operations analysis is an art, not a science; it uses tools of science; it tries to be objective like science; it attempts to quantify things; but the activity itself seems to be guided merely by human intuition and judgment, not by an organized methodology*.

To continue, the authors write "The phrase 'basis for decisions' implies that these quantitative aspects are not the whole story in most executive decisions." Maybe I don't understand English very well but the phrase implies just the opposite to me. A basis is a basis. A *quantitative basis* implies that we have put the decision in such a setting that even an executive can cope with it; he must be capable of distinguishing two from four. (He gets more money than an operations analyst because a hemibel thinker can distinguish only between two and six.)

One deficiency of many of the examples of the book is the very limited context in which the problems are put. The larger considerations (apparently to be supplied

* P. M. S. BLACKETT, *Operational Research*, Advance of Science, 1948.

by the executive) are ignored right and left even though many of them are certainly roughly quantifiable. For this reason the most convincing examples are those having to do with elementary tactical situations where it is a matter of deciding how to do a certain thing given a specific set of circumstances and specific equipment; i.e., problems so circumscribed as to be safely detachable from the larger considerations†. But when it comes to putting AA guns on merchant ships the analysis given (pp. 52, 53) is a fairly epsilonic part of the quantitative basis. How could any decision have been made without an estimate of the time rate of attacks per ship? At the very least one might have computed the over-all dollar installation cost and maintenance cost of AA guns relative to sinking losses; better, one might have tried to estimate the marginal utility of AA guns elsewhere. A still more useful analysis would have examined several alternative ways of reducing the hazard. To mention another example, the analysis of the circulation of U-boats (pp. 77–80) and the effects of various kinds of attacks seems too restricted in view of the fact that costs and payoffs of the attacks (both military and dollar) were largely left out of account.

Along the same line I cannot refrain from bringing up the little example where an ingenious analyst eliminated a waiting line (p. 3) by suggesting that a group of soldiers wash their mess kits in three tubs and rinse in one tub, instead of using two tubs for each operation. I give you verbatim an account of this by the mess sergeant: "Yeah, I remember that guy. He had some screwball idea that the mission of the Army was to eliminate waiting lines. Actually I had it all figured out that two was the right number of rinse tubs. With everyone rinsing in one tub the bacteria count would get way past the critical level. But we switched to one rinse tub while he was around because the old man says he's an important scientist or something and we got to humor him. Had damn near a third of the outfit out with the bellyache before we got the character off the reservation. Then we quick switched to three rinse tubs and really made a nice line. 'Nothing like a good line to get the men's legs in condition,' the old man says. He was right too. Six months later during Patton's dash across France we got stuck with a 30-mile cross-country hike to cut off a highway. The boys were in top shape and went the whole way in high gear."

Now I turn to another complaint. The book suggests that perhaps operations analysis will be useful in business and industry. Well I should say. It has been going on in business for at least a couple of generations with no sign of diminishing —quite the contrary. Does the book draw on any of this vast experience? Not a whit.

What do operations analysts do in business and industry? They provide quantitative bases for decisions of importance to management. They compare alternative arrangements of assembly lines and feeder lines. They design and redesign products to compare qualities and costs of production. They continually examine new materials with a view to substituting them for presently used materials. They estimate demand curves and sales under a wide variety of pricing policies, advertising policies, possible competing products, etc. They provide management with a vast statistical history of the corporate activities together with trends and forecasts for the next several years. They have cost accounting down to such a fine point that the contribution of the least product to the corporate income can be readily and accurately computed. You want to know whether and where to locate

† Charles Hitch, "Sub-optimization in operations problems," *J. Opns. Res. Soc. Am.* **1,** 87–99 (1953).

a new filling station in your neighborhood? The operations analysts of Standard Oil have a long list of factors you should consider, complete with weights. You have some brilliant little gimmick to add to an automobile? The operations analysts of General Motors will tell you just how much it will increase the price of the car, and how many additional cars will be sold as a result of it (making allowance for sales lost because the gimmick will annoy some people). Next time you inherit a decadent chain of grocery stores, rush out and hire a couple of operations analysts from A and P. Their theorems on inventory control, product display, loss leaders, and whatnot, will amaze you.

I have decided to manufacture and market my latest invention (an edible necktie whose delicate flavor lacks only a spot of gravy) and wonder how big a plant to build. A good market analyst will forecast my annual sales to within 15 per cent. How much of my budget should go into advertising and how should it be allocated between radio, newspapers, television, and rumormongers? Batten, Barton, *et al.* have it down to the dollar in a day.

The list of analysts goes on and on. Quality-control experts. Time-and-motion experts. Personnel managers (selection, training, promotion, incentives, etc.). Investment counselors. Product packagers. I could list a hundred given a couple of days and a file of *Fortune*.

The point is that the operations of business and industry have been subjected to analysis for a long time both in the large and in detail. It is quantitative analysis; it is objective analysis; it is useful analysis. Furthermore it is fairly comprehensive analysis. Management abhors making decisions in the dark; it has nurtured and supported this horde of operations analysts to fill its general demand for information about its entire spectrum of decisions. It is not surprising that business is far ahead of the military in analyzing its operations. Efficiency is of first importance in business because, generally speaking, survival depends on it. The aim of the military is success as soon as possible (hang the costs); efficiency is fine and sometimes necessary but definitely not of first priority.

In breaking into business we find a crowded field that is discouraging, but it is encouraging that business is already sold on analysis and is willing to pay well for cogent advice.

NOTE: Professor Morse had a preview of this review and for the benefit of the few who may not know what an exceptional man he is let me report that he not only made no protest but even suggested a change that would parry critics of the review. (Of course this does not mean that he endorses the review in any way.) I hope it is as clear to others that I have just been getting some opinions off my chest and that they are directed to all of us—not especially to Morse and Kimball.

A. M. MOOD
The Rand Corporation

M. H. QUENOUILLE, *The Design and Analysis of Experiment*, Hafner Publishing Co., Inc., New York, 1953, 360 pp., $7.50.

TO A dyed-in-the-wool experimental physicist the modern theory of experiment design may appear to be another of those impractical, esoteric activities indulged in by his more mathematically inclined colleagues whose manual dexterity does not qualify them for the more satisfying laboratory experimentation. Assuming that one could develop a method of determining the effect of a single variable when several other factors were changing simultaneously—why do things the hard way?

A properly designed experiment is one in which only the particular quantity under study is varied while all other variables are kept under control. The significance of the results will then be determined by the sensitivity of the measuring apparatus and can be expressed in simple terms by the theory of errors.

This is perhaps a somewhat simplified picture of the attitude of our experimental physicist but it does typify the approach of a physical scientist to a laboratory problem and indicates the need for wider acquaintance with these powerful and general statistical techniques on the part of laboratory-trained physical scientists desirous of engaging in operations research. For the operations analyst, taking the empirical approach toward analyzing an operation (an operations research is still largely an empirical endeavor), has to cope with the same type of complex interrelations and the same lack of environmental control that have bedeviled process engineers, agronomists, meteorologists, bacteriologists, and others who have had to measure quantitative relations in operating systems over which they have had little control.

For such persons this condensed and highly readable book by Quenouille fills a need for a relatively elementary but nevertheless complete exposition of the more useful types of experimental designs. These are presented in an orderly fashion and illustrated throughout with good practical problems chiefly from agriculture and biology. No extensive mathematical derivations are given since the author's primary objective is directed toward presenting the reader with a working knowledge of experimental design and an understanding of the principles governing it. References are made to the more erudite, but less expository, work of R. A. Fisher and the other pioneers of this field, should any of the readers wish to check the validity of the procedures and formulas. In fact, in some cases the rather detailed development of the analysis has been omitted with just a reference to the original work, in order to emphasize the purpose and interrelations of the different types of designs without losing these essential facts in a mass of detailed computation.

The author indicates, at various places in the text, the importance of adequate inspection of the raw data. "Such inspection, which is often thought unnecessary since the advent of statistical tests, is, in fact, all the more necessary and will often obviate the need for any extensive analysis." To which this reviewer adds—*amen*.

W. J. Horvath
Department of Defense

Fundamental Research in Administration: Horizons and Problems (Report of a Round Table), Carnegie Press, Pittsburgh, 1953, 89 pp., $2.00.

THE CUSTOM of the learned conference called to ponder a massive problem has become an interesting trait of American culture in the mid-twentieth century. In the points of contact between technicians and men of action it is especially fashionable. Memory has forgotten and history has not yet recalled how derided was the 'commission' in the early years of the depression, when then-President Hoover resorted over and over again to the device. But the device still has the virtues which it had then, as well as the faults. The commission or the conference makes little headway toward the actual solution of a problem, either in terms of an action solution or simply of an intellectual solution. But it does pool responsibility, prove by canvass that none present can solve what the others cannot solve, expose all to a discipline of courtesy to each other, provide a rostrum for mutual admiration, *and* after all its faults, also summarize the state of knowledge, identify possible leaders, and leave some stimulating thoughts.

Such is a strange beginning for a review of a book. But the book is the record of a conference concerning fundamental research in administration. The explicit purpose and the literal record leave one partly perplexed and partly embarrassed, for the participants often show little readiness to discuss a particular point of issue on the level on which such a point might be defined. Taken literally, the discussion is often not much good. But as is common and as we often know by experience, the literal discourse is a vehicle for another discourse, a rambling and unpredicted one, in which there is real meat. Not the heading or subheading but the anecdote and the assertion are the things said and worth saying.

Those present at the conference included a few among the high leaders of industry, Price of Westinghouse, Swensrud of Gulf Oil, Collyer of Goodrich, and more. There were also deans from MIT and California and Harvard, editors from *Business Week* and *Fortune*, and a good group from Carnegie. The occasion was the dedication of the new Graduate School of Industrial Administration at Carnegie Institute of Technology.

In the course of discussion there is an implication of the researcher asking what research he should do. There are also implications by the representatives of research that they possess technique without purpose, and in places, that they know how to learn laboriously what has long been known. The scientific proof that frequency of actual meeting is essential to the vitality of communications between officials who should work together may be important. May one not wonder, however, whether this was not earlier attributed to Roman knowledge of administration, by Shaw, or Shakespeare, or if not by them surely by Caesar and Cicero and other authors not unknown in American schools.

On the record of this conference the position of research, its character, and the conditions required for vitality were more clearly understood and stated by the men of action than by the men of thought. When an attempt was made to define 'fundamental research' the first illustration offered boggled the issue, whereupon one of the industrialists came forward with a statement in common sense terms which also make philosophic sense, and backed his definition with the claim that fifty cents of the research dollar in his company goes for such research.

The awkwardness about the meaning of research is a matter which must sooner or later concern operations research. The prevailing empiricism which avoids all questions of theory affects social scientists as well as physical scientists, and researchers of administration are included. The question remains, why is it that social scientists, trained in the concept of the culture and the culture process avoid rather than seek a definition of research that would be operationally based as a function of the culture process? This would be operational in meaning, in Bridgman's sense. Such thinking might lead toward radical solutions of some of the problems that are now only mauled in inconclusive controversy.

Many qualities of the book have been implied rather than specified so far. It is a short book and, though meandering, quick to read. At its worst it gives a true and concise epitome of inadequacies that are present among us. At such points no less than when it says good things and says them well it is stimulating. Scattered through it are nuggets. Those who profess to do research *for* administration may find it a good sample from the minds that seek to do research *on* administration.

George S. Pettee
Operations Research Office

W. W. Cooper, A. Henderson, and A. Charnes, *An Introduction to Linear Programming*, John Wiley & Sons, Inc., New York, 1953, 74 pp., $2.50.

DESPITE the small size of this volume, it is really two books bound together. The first (Part I, *An Economic Introduction to Linear Programming*, by Cooper and Henderson) presents a special case of the mathematical programing of a set of simple business decisions. The problem is to make the largest profit by selling mixed nuts, subject to prices for each kind of nut, prices for each kind of mixture, minimum specifications for the contents of each mixture, and maximum capacity for each kind of nut. This is a numerical example, so the meaning of the symbols can be verified step-by-step through the whole analysis (simplex solution). Although this example is neither compact nor elegant, it shows proper respect for the learning processes. Many readers, including the reviewer, would have had trouble translating the second book into the concrete terms of the first, without being led through a relatively simple example. Although this example is called "an economic introduction," it is free of the elaborate entities of classical economics. Noneconomists will have no difficulty with this part of the book because of any lack of familiarity with technical economics.

The second book (Part II, *Lectures on the Mathematical Theory of Linear Programming*, by Charnes) presents the essential materials of the first rigorously and in complete generality. The exposition is formal and orderly in the sense of a symbolic argument free of the kind of illustration already adequately provided. The presentation is carried along by both matrix algebra and geometry to help the reader visualize the method of solution of the problem. These parallel arguments simplify the treatment of such problems as degeneracy, and the means of arriving at a solution without reaching an impasse from this cause. Criteria are developed for the classification of optimizing models, at each stage of the computation, into (a) those having no finite solution, (b) those having a finite solution that has not yet been arrived at, and (c) those for which the solution has been found, i.e., for which a set of values has been found that is consistent with all the conditions of the problem and that minimizes or maximizes some assigned objective function.

This is the book for readers who have been following the general philosophy of formal programing but have not had the opportunity of working with actual problems. It presents the basic ideas lucidly, with a carefully chosen and consistent notation, and with skillfully worked out illustrative materials. A reader may start with no more mathematical technique than an understanding of fairly elementary algebra, and follow most of the text without too much difficulty. Definitions are introduced as required, and the more earnest reader is referred to publications that will increase his skill with the mathematics. The exposition is complete with computation forms, table layouts, etc., suitable for the solution of the system of simultaneous linear relations in which the problem has been stated. In all, the authors have produced an unusually readable treatise on this increasingly important branch of applied mathematics.

My main complaint is that this publication is not *three* books. Showing a single example and examining the general characteristic of the methodology does not give the reader a sufficient appreciation of the flexibility and resourcefulness of the approach. A third section, possibly as large as the first two combined, giving applications from widely differing subject-matter fields and requiring the construction of a wide variety of formal model structure, would complete the text. First the relatively

simple special case; then the formal treatise in full generality; and finally a wealth of demonstration in the logical expression of the problem. Problems with a more elaborate technology than the nut-mix illustration, and additional examples of the great flexibility of the 'slack-vector' device, might be especially helpful. The use of the model to guide the selection of relevant materials and to reject unnecessary information is a valuable art almost not mentioned in the present volume but one which could easily be integrated into the third book. This use gives additional point to the whole formal approach. I suspect that in many practical situations the formal symbolic statement of the problem makes as large a contribution to an analysis as does the exhibition of the solution. Perhaps the authors and the publisher might be persuaded to offer such a greatly enlarged edition.

EZRA GLASER
Bureau of the Budget

RONALD W. SHEPHARD, *Cost and Production Functions*, Princeton University Press, Princeton, N. J., 1953, 104 pp., $2.00.

DR. SHEPARD'S treatment of cost and production functions is clear and concise, although some degree of mathematical maturity and some familiarity with economic terminology are required of the reader. The proofs employ elementary concepts from topology and from the theory of convex bodies. Although the monograph performs a valuable service in emphasizing the difficulties in model building, particularly the difficulty of avoiding drastic restrictions on cost or production functions, the primary value lies, of course, in the mathematical interest, from the existence-theorem level, of the duality relations established between the cost and production functions.

The monograph presents a unifying treatment of two central economic concepts: production functions and (minimum) cost functions. If $x_1, \cdots, x_n$ are the inputs of n different factors of production and U is the output, a production function is, by definition, any suitable function relating U to the x's, say $U=\Phi(x_1, \cdots, x_n)$. Regarding $X=(x_1, \cdots, x_n)$ as a point in the space of the x's, i.e., in the input or factor space, we may write $U=\Phi(X)$. If Φ is convex as usually assumed and possesses adequate continuity properties, there exists a convex function $\Psi(U, X)$ homogeneous of first degree in the x's such that $\Psi(U, X)=1$ if and only if $U=\Phi(X)$.

If $p_1, \cdots, p_n$ are the prices of the corresponding n factors of production, $P \cdot X=\Sigma\, p_i x_i$ is the cost of producing the output U. The *minimum* cost of producing specified U, assuming P to be given and $\Psi(U, X)=1$, is a function $Q(U, P)$, which is convex and homogeneous of degree one in the p's. Shephard proves that the hypersurfaces $\Psi(U, X)=1$ and $Q(U, P)=1$ are polar reciprocals of one another with respect to the unit sphere. He further generalizes this result to cases of production functions with constraints.

The most useful results of the monograph are achieved through the introduction of the concept of homothetic production functions defined simply as being homogeneous in the inputs except for an order-preserving but otherwise arbitrary change of output scale. If Φ is homothetic, $U=\Phi(X)=g[\sigma(X)]$, where σ is homogeneous and g is monotone increasing in σ. If $f(U)$ is the inverse of $g(\sigma)$ we have $f(U)=\sigma(X)$. With no further loss of generality σ can be assumed to be of degree one. If Φ is homothetic, and only then, the cost function $Q(U, P)$ factors into $Q(U, P)=f(U)\,\Gamma(P)$, where Γ is homogeneous of degree one.

It is possible to interpret $\sigma(X)$ as an index number of the inputs and $\Gamma(P)$ as

an index of prices. This possibility leads to a natural discussion of the solvable case of the strict form of the problem of aggregation, i.e., the form for which path integrals or functionals are not acceptable. This problem of passing from microeconomic systems to macroeconomic models through the use of appropriate index numbers can be solved if and only if $\Phi(X)$ has the form $g[\sigma_1(X'), \sigma_2(X'')]$, where the space of X is the product of the spaces of X' and X''. In other words, X' includes part of the x's and X'' contains only the remaining ones; for example, X' may correspond to capital goods and X'' may correspond to primary factors of production. The functions g, σ_1, σ_2 must possess the properties of g and σ in the homothetic functions.

The most familiar examples of homothetic functions are the Cobb-Douglas functions, which correspond to a linear relation between the *logarithms* of the inputs and the output. The usefulness of this type of function in index definitions, and model building generally, is closely related to the fact that it possesses the homothetic property.

As an interesting application of the homothetic functions, Shephard closes with a generalization of G. C. Evans' formulation of the dynamics of monopoly. The factorability of the cost function is essential to this development.

Because of limitations of time and space in a monograph of this type, many interesting avenues of exploration must be neglected. Some consideration of the situation of joint products might have been instructive, however. Moreover, the essential role of optimization might have been further emphasized by a discussion of the relation between linear programing and optimum production functions.

FRANCIS W. DRESCH
Stanford Research Institute

RICHARD E. JOHNSON, *First Course in Abstract Algebra*, Prentice-Hall, Inc., New York, 1953, 257 pp., $7.35.

AS STATED in the author's preface, this book is a study of various algebraic systems arising in modern mathematics. The specific material treated is indicated in the ten chapter headings: I Basic Concepts, II The Real Number System, III Integral Domains and Fields, IV Polynomial Domains, V The Complex Number Field, VI Groups, VII Vector Spaces, VIII Linear Transformations and Matrices, IX Linear Equations and Determinants, X Other Algebraic Systems. Chapter X consists of one section each on linear algebras, rings, and Boolean algebras.

The algebraic systems considered are not extensively treated. However, the principal elementary properties of these systems are rigorously derived from fundamental definitions and postulates. Thus the book develops the common background of various algebraic systems and brings out the relationships among them rather than exploiting the systems themselves.

The general pattern of the author's presentation is to illustrate each new concept by a concrete working model prior to the development of that concept in abstract form. Little previous mathematics on the part of the reader is required. The presentation is straight-forward and the style is clear, thus making the book very readable.

Although the book is intended as a text for an advanced undergraduate or graduate mathematics course, it might well prove useful to the operations analyst who wishes to obtain a relatively painless, if not comprehensive, survey of the fundamental concepts upon which detailed algebraic manipulations are based.

JOSEPH O. HARRISON
Operations Research Office

P. F. STRAWSON, *Introduction to Logical Theory*, John Wiley & Sons, Inc., New York, 1952, 266 pp., $3.50.

COMMENTARIES by professional logicians on the relationship between systems of formal logic and statements in ordinary discourse ordinarily serve only to underscore the difficulty of defining a precise transformation system. It is encouraging therefore to find a scholarly attempt devoted to an evaluation of some of the features of ordinary discourse in terms of their relationship to logical systems. P. F. Strawson, a fellow of University College, Oxford has declared as his purpose that of showing "the points of contrast and contact between logical symbols and the behavior of words in ordinary speech."

In order to provide the introductory reader with a knowledge of the formal system being compared with ordinary speech, Mr. Strawson provides an excellent if short introductory discourse on the calculus of propositions and the calculus of classes, and proceeds to show some of the relationships between the newer logical systems and the Aristotelian logic. No attempt is made to present the reader with the more advanced tools of logical theory, nor is there a concern with proving theorems.

One of the most outstanding services this conversationally didactic volume provides is that of presenting, perhaps for the first time, a considered and complete discourse on the ambiguities inherent in expressions of customary language. It should by no means, however, be construed that the volume is devoid of significance for the graduate student. Indeed it may well be that the graduate student, having been led through the maze of logic, will be able to concern himself more fully with the musings of the author. Here, for instance, is a continuation of an earlier disagreement with Lord Russell's theory of descriptions Strawson expressed in an article, 'On Referring," *Mind* **59,** 320–344 (1950).

It would seem that the day is dawning when logic will serve a practical purpose in analyzing such things as contracts, legal briefs, executive systems, and indeed any system which is self-contained and which, in order to survive, must be internally consistent. Such systems presumably exist in everyday life. If, therefore, it is to be hoped that logic will be of service in outlining the implications of a system and the inferences which may logically be drawn from its presuppositions and its axioms, then such success will depend in large measure on the capability to translate from ordinary discourse into easily maneuverable logical constants. To this end the *Introduction to Logical Theory* may well serve as the first companion volume for the interpreter between systems.

W. E. CUSHEN
Operations Research Office

THOMSON M. WHITIN, *The Theory of Inventory Management*, Princeton University Press, Princeton, N. J., 1953, 245 pp., $4.50.

THIS is an interesting, well-written, scholarly book. The author is a theoretical economist who has attempted to apply the discipline of his science to practical inventory-control problems and has then gone on to examine some of the implications of his findings relative to the influence of inventories in the economy.

The first part of this book (Chaps. 2–5) will be of particular interest to JORSA readers. In it, Whitin examines the inventory-control problem of the firm. After providing a brief sketch of inventory-control systems in common use, he goes on to point out some of their deficiencies and to present some positive, practical sug-

gestions. One central problem in inventory control is the determination of the 'economic purchase quantity' or 'economic lot size' in manufacturing, since it is this quantity that determines the size of inventories. Two sets of cost factors must be considered: those that increase as inventories increase, such as interest, obsolescence, risk, depreciation, and storage; and those that decrease as inventories increase, such as quantity discounts, freight differentials, procurement costs, and setup costs in manufacturing. Due consideration of these sets of factors will determine the economic purchase quantity or lot size. The author's initial formulation is one that is well known in the literature of inventory control. He states that the economic purchase quantity or lot size should vary directly with the square root of the expected sales and procurement cost (or setup cost) and inversely with the carrying charge, i.e., interest, risk, depreciation, and obsolescence. He then goes on to show how quantity discounts, price anticipations, and variable storage costs should influence the economic purchase quantity.

The author, with praiseworthy care, keeps his algebra simple and clear throughout and, with due regard to practical application by business firms, suggests simple methods for calculation. The simplicity of his treatment of price anticipations is deceptive, however. To determine the influence of price anticipations on the economic purchase quantity, it is first necessary to predict the influence of the expected change in price on expected sales. In the text the author assumes that the elasticity of demand is unity or, in other words, that the expected change in price will not result in a change in expected dollar value of sales. Surely a word of caution would not be out of place here. Moreover, there is no attempt in this formulation to take care of the uncertainty of price anticipations. A more sophisticated treatment, even at the cost of additional complexity, might have been more useful.

In an original contribution of some importance, the author examines the inventory-control problem for style goods. He points out that merchandisers of style goods are not greatly concerned with ordering costs and carrying charges. Losses on surplus merchandise when inventories are too large, and losses of profits when inventories are inadequate are the main considerations. By use of ordinary marginal analysis he concludes that profits are maximized when the expected profits of stocking an additional unit are equal to the expected losses. To compute the expected profits and losses a probability distribution of expected sales must be constructed. But, as the author points out, "... much less is known about the demand for style goods than for staple goods, as often there is little or no sales history that can be used as a basis for demand estimates." Under these circumstances it is not possible to construct an actuarial frequency distribution, which must necessarily be based on observation of a large number of instances. The distribution of expected sales that Whitin refers to can only be a matter of hunch and estimation, and for that reason has been called a 'sham' frequency distribution. In these circumstances an alternative and perhaps more useful approach is afforded by Shackle's *focus-values* theory (G. L. S. Shackle, *Expectations in Economics*, Cambridge University Press, 1949). Shackle contends that an individual will concentrate his attention on two possible outcomes of any given action, one the *focus-gain*, which epitomizes what he stands to gain, and the other the *focus-loss*.

One of the main contributions of this book lies in its application of the theory of inventory control to broader problems of economics. It has been frequently held in the literature of economics that firms attempt to maintain a constant ratio of inventories to sales, and, on the basis of this assumption, various explanations have been offered of the relation between changes in the level of inventories and the business cycle. Data on inventory-sales ratios, however, indicate that this ratio

decreases in a period of expansion and increases in a period of contraction. Whitin's theory that inventories vary with the square root of sales is consistent with the data and has important implications for the theory of the business cycle.

The concluding section of the book considers inventories in the national military establishment and contains an interesting application of game theory to the problem of military value.

ALVIN KARCHERE
Operations Research Office

GEORGE P. BUSH AND LOWELL H. HATTERY, editors, *Teamwork in Research*, The American University Press, Washington, D. C., 1953, 191 pp., $4.00.

THIS little volume is adapted from the proceedings of the Third Institute on Administration of Scientific Research and Development presented at Washington, D. C., by The American University with the cooperation of the National Research Council and the American Association for the Advancement of Science.

The book is essentially a collection of 16 speeches, and, as usual, although 16 speeches by 16 different people frequently make interesting listening, they tend to make dull reading if one tries to read through a book of them. This is particularly true since some of the speeches were apparently prepared in response to a suggested topic not necessarily of primary interest to the speaker.

However, the book is interesting to browse through, and contains many ideas of value in connection with the central problem of *maintaining creative scientific activity at a high level in group research.* Tuve and Gibson give interesting discussions of the development of the Section T pattern of research organization, in which Tuve says, " 'Teamwork' is always development; research is an individual activity," and Gibson says, "Applied Science describes the sphere in which the Section T pattern is designed to operate." Pettee, in discussing teamwork in operations research formulates an interesting definition: "We study operations in order to arrive at results that will be useful to operators." He states that, in operations research, "Teamwork *across disciplines* is the *normal* condition of work."

G.S.

RAYMOND L. WILDER, *Introduction to the Foundations of Mathematics*, John Wiley & Sons, Inc., New York, 1952.

THIS well-written introductory treatment should be of interest to one who, from a cultural rather than a utilitarian viewpoint, is interested in inquiring further into the *nature* of mathematics. Part I, Fundamental Concepts and Methods, contains chapters on the axiomatic method, theory of sets, ordinal numbers, the real number system, and groups. In Part II, Development of Various Viewpoints on Foundations, the history, the philosophy, and the cultural setting of mathematics are discussed.

G.S.

BUSINESS DECISIONS

FAIR'S paper on machine computations of business decisions in the August issue of JORSA was intended to be more provocative than conclusive. It provoked a column of discussion in the Editorial Notes of the October *Fortune* which

concludes, properly enough, that it would be premature for executives to start worrying about their own technological unemployment.

G.S.

Industrial Operations Research

THE OPERATIONS RESEARCH OFFICE has printed a speech, *The Application of Operations Research to Industry*, by Ellis A. Johnson, presented at the Fifth Annual Industrial Engineering Institute, University of California, January 31 and February 3, 1953. (Copies of this 61-page publication may be obtained free on request to the Operations Research Office, The Johns Hopkins University, Chevy Chase, Maryland.)

In this speech, Dr. Johnson provides a cogent analysis of the current status of operations research, with particular emphasis on methodology. The history of operations research is outlined briefly; although its beginnings go deep into antiquity, its modern growth and application were slight until World War II, when techniques and applications developed rapidly as an aid to military management, especially in combat operations.

Today, in addition to organizations doing operations research for the various defense establishments, there are more than 60 American business firms and scientific and educational institutions either definitely interested in the field or actively contributing to its further development. These are enumerated.

Present methods of operations research are more comparable to those of the basic sciences than to engineering. Although many of the roots of operations research are held in common with industrial engineering and management counseling, operations research differs in its more conscious recognition of the need to use specialists, highly skilled in various fields of knowledge, to work in more closely integrated team research.

Methods of operations research are outlined, and the following topics discussed in detail:

Relation of the Operations Analyst to the Executive. As an aid to decision making for the executive, operations research is shown to have an important place. Organization charts are provided to show the various sources of information available to the executive, and how these interact to influence executive decision. It is emphasized that personal salesmanship as well as a written report is needed to convey operations-research results properly to the executive.

Operations Research Checklist for Solving Action Problems. The methodology of operations research is explained through a detailed discussion of the checklist. The fifteen-point list is broken down into two parts: seven points deal with the formulation of the problem (possible courses of action for the client-organization and of competitors) and the remaining eight with calculation of the conclusions and recomendations which are supplied to the executive.

Some Selected Analytical Tools Used in Operations Research. The analytical tools, seven of which are examined, include such techniques as the use of probability and statistics, the Monte Carlo method, and the theory of games. The importance of using computing machines to solve problems set up by means of the analytical tools is indicated.

Simple Case Histories in Operations Research. Among the simple case histories cited are several that have been reported in the Journal of the Operations Research Society of America. These include studies of optimum harvesting sched-

ules on a large New Jersey farm, of failures of airborne electronic equipment, and of the effect of sales promotion on sales volume of a food product. Operations research conducted by Dr. Johnson in a military situation in World War II is described, and its effectiveness indicated.

C.P.C.

Books Received

Willard Van Orman Quine, *From A Logical Point of View*, Harvard University Press, Cambridge, Mass., 1953, 184 pp., $3.50.

Harry G. Romig, *50–100 Binomial Tables*, John Wiley & Sons, Inc., New York, 1953, 172 pp., $4.00.

Morris H. Hansen, William N. Hurwitz, and William G. Madow, *Sample Survey Methods and Theory*, in two volumes, John Wiley & Sons, New York, 1953; volume I, 638 pp., $8.00; volume II, 332 pp., $7.00.

Russell L. Ackoff, *The Design of Social Research*, The University of Chicago Press, Chicago, 1953, 420 pp., $7.50.

E. H. Mac Niece, *Industrial Specifications*, John Wiley & Sons, Inc., New York, 1953, 158 pp., $4.50.