

not forget that it is essential, and that it has made some of the greatest contributions to science. Maxwell's contribution to the electromagnetic theory, to which reference has been made, was a *tour de force* of deductive reasoning in mathematical form; the Einstein theory is also a *tour de force* of similar deductive reasoning. The scientific world is this year honoring the fiftieth anniversary of the publication of a treatise by Josiah Willard Gibbs, of Yale University, which made thermodynamic chemistry an exact science. "Without his work many phases of modern industry might still be groping experimentally, trying to discuss laws which he set down before they began"⁴—another gigantic contribution of deductive reasoning. In the field of management Taylor's imagination stimulated a line of investigation in which inductive and deductive reasoning by Carl Barth gave us formulae that put the art of cutting metals on a scientific basis and made these readily available through a slide rule in practicing the art.

No industrial organization is complete which does not possess the genius correctly to apply deductive reasoning to the facts of management which are discovered, to make decisions governing actions with the highest probability of success, and to map out lines of investigation with high probability of important discoveries. This is an important function of committees.

V. The Search and the Re-Search for Facts

In all the sciences utilized by management, particularly in the social sciences and in the science of management itself, the outstanding achievement of recent years has been improvement of the technique of finding and measuring facts. Interest and discussion have been focused on this first important element of the total process of arriving at a decision or solution, rather than the succeeding elements of the total process.

Before there is conscious and highly organized effort to ascertain and measure facts, data are made available by casual observation in experience, and in time of special need by deliberate, conscious observation and by drawing on the intuitions of wise and experienced authorities. Casual observation is unquestionably the most elementary of fact-finding methods, but intuition, which sums up a mass of subconscious casually observed facts, is of great value. It is sometimes indispensable, for intuition frequently

⁴New York Times Magazine, November 28, 1926, p. 6.

discloses master facts, or generalizations from facts of personal experience, which elude capture and measurement by any fact-finding technique and yet may give the key to the solution of a problem. These intuitions may be of service on the one hand by suggesting research for facts by developed techniques, or on the other hand, after scientific methods have made their contributions, by stimulating analysis and appraisal along lines which solve the problem.

The qualitative method also is not obsolete. It will always be important. There is no controversy between qualitative and quantitative methods. In fact the qualitative method is essential to the quantitative method. *What* does the quantitative method count and measure? Try to determine that *what* without the qualitative method! And after the quantitative method has counted and measured, it is frequently discovered that it has not done so without some uncertainties, and it is with respect to these uncertainties that the qualitative method may again step in and give the key to the solution of a problem.

But it must be emphasized that the quantitative method—the statistical method—is the great achievement of method in the social sciences in recent years. Our sociological and industrial literature is full of it, and its nature and uses are familiar to most executives. It was a great discovery that facts of nature—inanimate and animate—have systematic relationships which may be measured; that these measurements disclose "master facts" not apparent to casual observation—norms, trends, relationships of frequency, coincidence and sequence. Most of the recent progress that has been made in psychology, economics and sociology, in perfecting methods of education, in treating mental and moral defectives, in measuring price trends and relationships, in analyzing consumption and markets, in forecasting industrial tendencies, in establishing budgets and other standards of control, is to be credited to the method of quantitative measurement. However, notwithstanding its importance, in fact because it is so well known and so highly valued, I desire to turn our attention to its principal limitations, which are usually not kept sufficiently in mind.

VI. Limitations of the Quantitative Method

1. The regard for quantity in many instances compels a practical (although not necessarily an intellectual) disregard for exactness of quality, and results in the setting up of more or less unreal units of ob-

servations and measurement. A basic assumption of quantitative measurement is that units of a counted and measured group are homogeneous, but many phenomena appear in continuous rather than discrete variation and refuse to conform to that assumption. Furthermore, problems are defined and their factors defined as our conceptions, attitudes and habits discover them. What is a farm; work animal; capital; income; depreciation; surplus; dollar; building; machine; tool; expense; addition to capital; raw material; worked material; tubercular victim; criminal; residence; factory building; and so on? The most critical step in a statistical investigation in the social sciences and one of the most difficult, is definition of the unit of observation; and an equally practical difficulty is getting the observed units listed—included or rejected—accurately with respect to the definition. Even those units which we regard as exact—dollars, pounds, feet—may not have great value in the solution of a problem except as they relate to associated qualities which cannot be included in the measurement.

2. Although the method of quantitative measurement reveals facts of relationship such as relative frequency, coincidence and sequence, it is only in exceptional instances, and then not without doubt, that it reveals relationships of cause and effect. Statisticians appear now to place less value on the method of partial correlation than formerly; it is highly suggestive and indicates lines of further investigation, but only when the correlation is very, very high is it regarded as indicative of any dependable cause and effect relationship.

3. Another limitation of the method under discussion is that it is not yet able to measure the data of a problem which are contributed by consciousness, by individuals as original and independent sources of energy, by individual and group "interests." Individuality implies heterogeneity of units. Measurements of this kind are vital in problems involving explanation, prediction and control in the field of managerial activity. For instance, we can after a fashion quantitatively measure the labor turnover in an organization, but we cannot yet measure the emotional stimuli and reactions which are the causes of the turnover. There are intimate and vital controlling facts of managerial relationship beyond the reach of any existing technique of quantitative measurement.

4. Furthermore, a statistical solution is always the determination of a definite, detail question of fact, which is but a fraction of an integral managerial

problem. We must remember that it is a process of fact finding, of "master fact" finding. A statistical investigation is a definite, restricted, laborious, time-consuming process. As executive one is confronted by a problem and one requests a statistical staff to ascertain facts within the scope of their technique. But those are not all the facts involved in making a decision. And in the meantime the problem grows with the passing of time, and the quantity and variety of pertinent facts increases. The statisticians contribute their findings, but these are but part of the data from which conclusions must be drawn and on which decisions are based. A science is so vast that total solution by methods of quantitative analysis of specific detail problems is inconceivable.

5. Finally, in the present state of the science and the art of quantitative measurement generally only those phenomena of conduct are quantitatively measurable which represent mass or group habits more or less rigidly fixed. The most magnificent achievements of quantitative measurement have been in the fields of astronomy and biology. Day by day, year by year, century by century each star of a universe of stars runs its appointed course, and measurements made in 1850 will hold good, except for the human errors involved, in 1950. Therefore, we can keep time and predict eclipses to the second. Anatomical and physiological characteristics of species are mass habits which change by such small increments that apparently they do not change. The modal length and the dispersion about the norm of the English sparrow will probably be the same in 1956 as in 1926. There are certain human mass habits having a biological basis—marriages, births and deaths—which change sufficiently slowly to permit valuable statistical measurements. Even mass habits relating to economic activity are profitably measurable, as is evidenced by barometric indexes. Yet here we get on less certain ground, for a sufficient number of mass economic habits, relatively stabilized during a period of relatively stable environmental influence before the war, are now unstable. Some of the formulae resulting from quantitative measurements made before 1914 are now in doubt.

Management is largely concerned with human conduct and, we are beginning to realize, with elements of conduct of which there is great variability among individuals. We may be able to assume for instance that there will be some sort of standard mass habit reaction to wage payments, but may we continue to