into existence; research units of individual business organizations, cooperative research organizations serving groups of enterprises, independent research organizations equipped to serve industry in a professional capacity, and research units of educational institutions designed to serve industry as well as to train young men in research technique.

5. The conclusion is inescapable that research has become an important function in management, that it is a responsibility of management to stimulate, support and utilize it, and that, for wise utilization, management should keep itself informed concerning undertakings, contributions and methods of research.

II. Research as an Aid to the Development of a Science of Management

This complexity of the industrial organization, and the consequent complexity of problems of management, has inspired efforts towards what is essentially standardization of elements of the managerial situation of far-reaching importance. In increasing number, enterprises are defining purposes, which is a standardization of objectives; defining policies, which is a standardization of general methods of achieving objectives; and formulating procedures, which is a standardization of particular methods of achievement; the underlying purpose of these efforts being to substitute constants for as many as possible of the variable elements in a managerial situation. Likewise industry as a whole (and this is the significance of the management movement) is attempting to define universally applicable policies and procedures, or at least discover universally applicable methods of defining these in any particular situation; and to this end it is searching for a body of underlying principles, a set of standards, a science of management. Furthermore, recognizing that progress is but a continuing adjustment to an ever changing environment, and that there will always be in industry as a whole and in each particular managerial situation, new elements and new problems, management is striving for principles and methods of solving this succession of variable problems with promptness and with maximum probability of accuracy.

It is inconceivable that progress in this direction can be substantial unless industry recognizes research as one of its functions, and has as much concern in research—its nature and its methods—as in any science or art in which management now has concern. It is for this reason that the Taylor Society inaugurates today a series of sessions on methods and instruments of research.

III. The Evolution of a Science of Management

Assuming that we do have the beginnings of a science of management, this embryonic science will undoubtedly evolve through those stages which, with variations, have been common to the established physical and social sciences. In striking respects the social task of "thinking out" a science is analogous to the individual task of "thinking out" a solution of an individual problem. Either process may be indicated crudely as follows:

1. a. Imagination, or more likely, uncertainty about what action to take in a concrete situation, creates a problem. This establishes the necessity of examining the pertinent facts for the purpose of deriving a conclusion or making a decision; which stimulates—

1. b. Inductive reasoning, or analysis of the facts, which yields general conclusions concerning the facts. The application of these general conclusions to the particular problem, by using them as premises in a process of deductive reasoning, results in—

1. c. Formulation of alternative conclusions or decisions, no one of which is satisfactory because it does not solve every phase of the problem. The most satisfying of these conclusions is adopted as the basis for immediate action; the others stimulate the beginning of a new cycle, as follows—

2. a. Redefinition of the problem, including active exercise of the imagination, and the accumulation of additional pertinent facts; which stimulate—

2. b. Analysis of the more complete facts and derivation of more substantial general conclusions. Deductive application to the problem of these more substantial premises results in—

2. c. Formulation of more positive conclusions or decisions. But new experience discloses the inadequacy of these conclusions or decisions, which stimulates the beginning of a new cycle, as follows:

3. a. Further redefinition of the problem, aided by imagination, and refinement and extension of methods of accumulating additional pertinent facts; which stimulate—

3. b. More intensive and fruitful process of inductive reasoning; more rigid deductive reasoning from more stable premises afforded by the more abundant facts; which stimulate—

3. c. Formulation of conclusions or decisions in the nature of formulae concerning relationships of coincidence, sequence, relative frequency, or cause and effect; the beginnings of a science which permits formulation of standard and dependable procedures in the arts governed by the science.

But new experience, the discovery of new facts, causes questioning of formulated principles, or at least of their completeness, and stimulates the beginning of a new cycle; and so on *ad infinitum*.

It should be realized that this picture of the total process of "thinking out" a problem or a science is artificial in that the elements of the process in actual experience are not so separable. The whole should be conceived as a shuttle motion back and forth between facts and conclusions, of such rapidity that inductive and deductive reasoning become but different aspects of the same integral process.

Students of method are generally agreed that the evolutionary development of method in the several sciences has proceeded, with variations, through these stages:

1. *The Deductive Stage*: in which emphasis is on the processes of reasoning from facts and not on the quality, quantity or methods of securing of the basic facts;

2. *The Qualitative Stage*: in which emphasis continues to be on deductive reasoning, but in which attention is given to securing a greater quantity of facts and especially to defining and classifying their characteristics;

3. *The Experimental and Quantitative Stage*: in which deductive reasoning continues to be the essential final step in the solution of a problem, but in which emphasis is placed on observation of facts under controlled conditions and on analysis and comparison of large quantities of facts.

It is to be observed that in these brief and inadequate statements concerning the development of scientific method, three elements have appeared and reappeared—the accumulation and analysis of facts, imagination, and deductive reasoning. Because imagination can and so frequently does deceive and mislead as by pretending that the results of its processes are established facts or conclusions, we are inclined to underestimate its importance. Because deductive reasoning was highly developed early in our culture, we have become so accustomed to it as to forget its significance. That which we are now inclined to emphasize, because its technique is being enriched every day, is the importance of the processes of accumulating and measuring facts. And it is with this that I am principally concerned in this paper. To be complete and impartial, however, I desire in passing to say a word about imagination and deductive reasoning.

IV. Imagination and Deductive Reasoning

Imagination is one of the outstanding forces in the development of a science. It may play us false when it presumes to tell us what the facts of a case *are*, but it is a great constructive force when it tells us what undiscovered facts there *may be*—what to search for in the wilderness of the unknown. This must have come home to those of you who have read Pupin's autobiography. He speaks with authority on the origin of the electromagnetic theory of light and matter, which has in our day revolutionized the physical sciences. Faraday, stimulated by experiments in his simple laboratory, dreamed about it; Maxwell, the mathematician, the deductive reasoner, proved it must be so; Hertz in his laboratory proved that it is so. Says Pupin:[2] "The general development of this view was due to the gradual development of new physical concepts which were born in Faraday's mind and existed there in a poetical vision; . . . In every creative physicist there is hidden a metaphysicist and a poet . . ."

No industrial organization is complete which does not include one or more dreamer of dreams to originate problems for its research group; no science of management can ever develop without the contributions of those who dream about the management of the future. But these dreamers must know what are dreams and what are facts; they must have that quality of which Pupin says:[3] " . . . in spite of his wonderful imagination and his free use of it, no investigator ever succeeded better than Faraday in drawing a sharp line of division between the new facts and principles which he had discovered and the visions which his imagination saw in the still unexplored background of his discoveries."

Deductive reasoning is the element of total process immediately preceding a conclusion or solution. This method is as all-pervading and essential as is the air we breathe. Facts receive a practical value by treatment in the crucible of deductive logic. Because on occasion its premises or its processes may be wrong is no fault of this process; it is the fault of the user. We should

[2] "From Immigrant to Inventor," p. 222.
[3] *Ibid*, p. 223.