Mr. Soggan

85th Congress, 2d Session — COMMITTEE PRINT

THE IMPACT OF THE PATENT SYSTEM ON RESEARCH

STUDY OF
THE SUBCOMMITTEE ON
PATENTS, TRADEMARKS, AND COPYRIGHTS
OF THE
COMMITTEE ON THE JUDICIARY
UNITED STATES SENATE
EIGHTY-FIFTH CONGRESS, SECOND SESSION
PURSUANT TO
S. Res. 236

STUDY No. 11

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UNITED STATES
GOVERNMENT PRINTING OFFICE
20609 WASHINGTON : 1958

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FOREWORD

This study was prepared by Prof. Seymour Melman for the Subcommittee on Patents, Trademarks, and Copyrights as part of its study of the United States patent system, conducted pursuant to Senate Resolutions 55 and 236 of the 85th Congress. It is one of several being prepared under the supervision of John C. Stedman, associate counsel for the subcommittee.

Earlier reports on the work of this subcommittee have noted the great changes in our economic and industrial system since our patent laws came into being. As we put it in January 1956, "the industrial and technological economy of today bears little resemblance to that of yesterday * * *. The garret, garage, or basement inventor to a marked extent has given way to the laboratory technician who is both scientifically trained and versed in the latest techniques of experimentation and invention. The independent 'lone wolf' inventor has given way to the coordinated group activity of the research laboratory." What do these changes augur for the patent system? How shall the patent system respond, the better to discharge its constitutional purposes?

Professor Melman addresses himself to these issues, taking for his subject of inquiry the highly important, highly organized, extensively staffed research laboratories that operate today at both industrial and university levels. In this milieu, he concludes that the patent system, whatever its past contributions and its value and virtues in other respects, contributes little to the progress of science and useful arts. This conclusion, without doubt, will be greeted with skepticism by some and with vigorous disagreement by others. Nevertheless, Professor Melman has posed a serious issue and subjected it to thoughtful and competent inquiry. I hope, and expect, that those who challenge his views—and there will be such, I am sure—will approach the subject and his handling of it with the same measure of competence and thoughtfulness that he has shown. The subject is too important and complex to warrant anything less.

Professor Melman is well fitted to speak on the matter at hand. As a member of the department of industrial engineering, Columbia University, he has a longstanding, active and down-to-earth interest and experience in the subject of industrial productivity and research. He has carried out varied industrial studies while on the faculty of Columbia University. He is the author, among other publications, of Dynamic Factors in Productivity, a book which has received wide attention in this country, Europe, and Japan since its publication in 1956, and which is the product of 5 years of research and extensive consultant work with various industrial concerns.

In publishing this study, it is important to state clearly its relation to the policies and views of the subcommittee. The views expressed by the author are entirely his own. The subcommittee welcomes the report for consideration and study, but its publication in no way signifies or implies acceptance or approval by the subcommittee or its members of the facts, opinions, or recommendations contained in it. Such publication does, however, testify to the subcommittee's belief that the study represents a valuable contribution to the literature concerning the patent system and its operation, and that the public interest will be served by its publication, distribution, and consideration.

JOSEPH C. O'MAHONEY,
Chairman, Subcommittee on Patents, Trademarks and Copyrights, Committee on the Judiciary, United States Senate.

MAY 16, 1958.

CONTENTS

PART II. THE USE OF TECHNICAL KNOWLEDGE AS PROPERTY

PART III. THE INTERRELATION BETWEEN THE PRODUCTION OF TECHNOLOGY AND ITS USE AS PROPERTY

THE IMPACT OF THE PATENT SYSTEM ON RESEARCH

By Seymour Melman

CHAPTER I. INTRODUCTION: THE PROBLEM DEFINED

There is a growing inconsistency between requirements for fruitful technical research and the effort to operate a patent system. That is the main finding of this inquiry into the relation between the patent system and modern technical research.

The historical justification of a patent system is rooted in two propositions: first, that it is possible to identify the creators of new articles and techniques; second, that the privilege of exclusive property rights granted for a given period will yield a material return to the creators of new things, and will thereby encourage them to further creative work.[1]

The first of these assumptions implies that scientific research and technological development are carried out under conditions that enable one to specify the particular person to whom a creative act may be attributed. The second assumption implies that the granting of the patent right has a substantial effect in promoting further effort in scientific inquiry and technical application of the results.

A. THE PROBLEM OF THIS STUDY

Two problems are at the center of this study. What are the conditions under which technical knowledge is produced? The answer to this question should indicate whether it is indeed possible to identify inventors and inventions in a workable way. This problem is surely of more than formal interest, for the course of recent patent litigation has indicated that the criteria for invention—often tied in with the identification of the inventor—lie at the heart of many cases in which patents granted by the United States Patent Office have been held invalid by the courts.[2]

The second problem of this inquiry is the question: What has been the effect of the patent system on the promotion of science and the useful arts? This question is a critical criterion for the evaluation of the functioning of the patent system. Clearly, it is possible to suggest many criteria by which to evaluate an institution like a patent system. Patent arrangements have far-reaching effects on economic institutions, on property relations, on profits of industrial firms, on concentration of control in industry, on monopolistic practices

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[1] Legally speaking, our patent system is based upon art. 1, sec. 8, of the Constitution of the United States, which provides that "The Congress shall have Power * * * To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."

[2] Of 50 inventions recently held invalid by the U. S. Court of Appeals, 43 were invalidated on grounds of "lack of invention or anticipation." Hearings on the American patent system, before the Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee on the Judiciary, 84th Cong., 1st sess., at 184 (Oct. 10–12, 1955).

20609—58——2

3. Measuring research activity

In a review of the operation of research activity in industrial firms and other laboratories there arises the problem: How much is produced in these facilities? It should be made clear at the outset that there is no sure way of gaging or defining output of technical knowledge or technical design.[10] Therefore, it is only possible to measure the activity in these facilities by counting some of the inputs that are involved. We can measure the man-hours or the funds that are used up in the operation of these facilities.

[10] It is, of course, possible to count the number of patents taken out by a research unit. The significance of such counts for gaging output is limited, however, by the fact that intensity of research activity is not necessarily reflected in the number of patents obtained, even where patenting is a regular adjunct to research. See ch. VII. On the other hand, the output of technical papers may at times be a rough indicator of research activity.

(antitrust policy), on the role of Government as a decision maker in industry, and on the scope and characteristics of the legal profession. Any one of these areas of effects could be utilized for the purpose of evaluating the functioning of the patent system.

This report deals with only one aspect of the effects of the patent system, namely, What has been the effect of a patent system on the promotion of science and the useful arts? This criterion corresponds, to the end in view stated in the Constitution of the United States under which the Congress was empowered to establish a patent system. Moreover, the test of promotion of science, in both its basic and applied connotations, is important in its own right. For the progress of science and its application to production is a major factor in the capability of any country to attain high levels of material well-being.

B. SCOPE OF THE STUDY

Each of the problems noted above is the subject of a separate part of this study. The first part deals with the conditions of the production of technical knowledge. Here the attempt is made to marshal data from industrial, university, Government, and other laboratories which bear on the ways in which research and development are actually organized and carried out in many fields of science and engineering. These aspects of research are closely relevant to the problem. This involves identifying those who create new articles and techniques. It also involves making clear what is meant by "new technology" (ch. II). This leads in turn to an examination of the various groups and individuals who contribute to this production, in other words, the division of labor and interdependence in the production of technical knowledge (ch. III). In chapter IV the inquiry turns to the question of how the producers of technical knowledge are paid, a matter closely related to the problem of incentive for performance of this type of work. A different aspect of technical research, namely, the worth of new knowledge, is explored in chapter V. This, too, has a bearing on the problems of incentives. Finally, chapter VI analyzes the determinants that influence, shape, direct, and limit the production of new knowledge through technical research, whether conducted under industrial or nonprofit auspices.

The second part is concerned primarily with the use of technical knowledge as property and the implications that arise from such use. Chapters VII and VIII focus attention on the main effects that flow from the use of patents by business firms and universities, respectively. Chapter IX deals with the relationship of patents to the progress of science and technology. In order to bring out more clearly this relationship, chapter X delves into the speculative inquiry: What would be the consequences if we had no patent system?

A third part, represented by the final chapter (ch. XI), examines the relationship between the subjects discussed in parts I and II, to wit, the conditions covering the production of knowledge, and the operation of the patent system as a way of promoting science and the useful arts.

C. CHARACTERISTICS OF THE DATA

One of the problems involved in an inquiry of this type is the appropriateness of the methods used. The investigation had to be designed to enable the writer to reach conclusions that are meaningful in terms ment and university laboratories is typically characterized by division of labor and interdependence among the investigators. The division of labor is expressed in the variety of occupational skills that are brought to bear upon particular problems. The interdependence in the work is made evident by the utilization of prior knowledge and the know-how of contemporaries engaged in related tasks. It is doubtful whether the classical inventor of the type visualized by the patent system is today a major factor in technical development.

A. INDUSTRIAL RESEARCH LABORATORIES

These characteristics in industrial research laboratories become apparent when one examines the variety of occupations found, in the course of this study, to exist in several large laboratories. In one major electronics laboratory the composition of the scientific research personnel was as follows:

Mathematicians	25
Metallurgists	15
Chemists	50
Physicists	75
Electrical engineers	600
Mechanical engineers	50

In a petroleum firm's central laboratory the following breakdown appeared:

Chemists	278
Geologists	2
Physicists	6
Mathematicians	16
Chemical engineers	900
Civil engineers	200
Electrical engineers	120
Mechanical engineers	480
Petroleum engineering specialists	16
Other engineers	100

In the same laboratory, this variously-trained personnel was assigned to an even greater variety of designated research and development jobs,[13] to wit:

Analytical chemists
Chemists
Research chemists
Staff chemists
Division director
Chemical engineer
Development engineer
Electrical engineer
Engineer
Metallurgical engineer
Process engineer
Inspector
Laboratory assistant
Technician
Engine operator
Engine mechanic
Pilot plant operator
Mechanic
Research librarian
Industrial hygienist
Toxicologist
Products technologist
Research physician
Technologist
Research physicist
Research engineer
Foreman
Process foreman
Mechanical foreman

[13] This list includes only those directly engaged in research and development work. There are, of course, others engaged in activities necessary to support the research and development function. These include the usual clerical, bookkeeping, accounting, purchasing and legal personnel; also, those engaged in routine maintenance of building operation such as janitors, guards, routine mechanics, and painters.

constituted the cross section of industrial research activity recently reviewed by the National Science Foundation.[5]

The engineers and scientists in these industrial research laboratories numbered about 7,700. The National Science Foundation has estimated that in 1954 altogether 157,300 scientists and engineers in private industry were engaged in research and development.[6]

This means that the firms sampled here accounted for about 5 percent of the total research and development personnel in industrial research laboratories. The sampled laboratories are not only important in their own right; they represent a substantial sector of the total research and development activity. These laboratories also account for a substantial amount of patenting activity, as will be reflected in the later chapters of this report.

A further interest in these laboratories of large size stems from the increase, in recent years, of basic research in these laboratories. This means investigations into the characteristics or phenomena which are at least one or two steps removed from the production of knowledge that is aimed at particular product or production method utilization. During 1953–54 basic research amounted to 4 percent of industrial research expenditures.[7] Underlying this statistic the report gives the following definition to "basic or fundamental research" within business-sponsored laboratories: Projects which are not identified with specific product or process applications, but rather have the primary objective of adding to the overall scientific knowledge of the firm.

Attention is directed to the last phrase "* * * of the firm," which gives to basic research an altogether different meaning from the usage among university scientists. There, the relevant realm for exploration by scientists is not the knowledge of the firm, the university, or even the country, but man's knowledge of phenomena. In the nonindustrial laboratory the promotion of science and its application is not limited by the requirement of serviceability to the firm, however broadly that may, in some cases, be construed.

Since the four sampled laboratories are of large size, they do not necessarily represent certain of the operating characteristics that would be found in many smaller laboratories in industrial firms. The fact is, however, that in 1954 about 70 percent of research and development in American industrial firms was carried out by 375 of the largest companies, which represented some 2 percent of the sample of firms recently studied by the National Science Foundation.[8] Accordingly, concentration of attention in this study on the larger units is in keeping with their relative importance in the industrial research scene. Moreover, a substantial literature has been devoted to presentation of the managerial and other methods of the larger industrial laboratories.[9]

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[5] National Science Foundation, Science and Engineering in American Industry (1956).

[6] Id. at 19.

[7] Id. at 5–6.

[8] Id. at 3.

[9] See, e. g., Bush, Bibliography on Research Administration (Washington, D. C.: The University Press of Washington, D. C., 1954); Anthony, Management Controls in Industrial Research Operations (Boston: Harvard University School of Business Administration, 1952), see pt. IV, and the bibliography on pp. 513ff. Collections of papers on research management practices have been published by the American Management Association, and by the annual conference on industrial research management of the department of industrial and management engineering of Columbia University (see note 27, infra).

> * * * Just before the last war, we were interested in developing a catalytic cracking process and were working on one called Fluid Catalytic Cracking. At the peak of that effort, we had about 200 people of all sorts working on the process. Some of these people were professional people and some were nonprofessional. In the group, we had physical and organic chemists; we had physicists; we had engineers of all types; we had lawyers, analysts, mechanics, operators, etc. The Research Division was working on part of it, the Process Division on another part, and the Development Division was doing the engineering and economic studies. The Baton Rouge laboratories were running a huge pilot plant and the Esso engineering department engineers were designing the commercial units. In addition to that, the patent and legal people were checking to be sure that if we did develop the process we would have patent protection on it. If we have to put all of those things together and develop the process in a short period of time, it is obvious that individuals today cannot do industrial research successfully. It has to be done by groups of coordinated people.[14]

From the standpoint of conventional management and administration, this type of division of labor requires considerable organizational effort in order to integrate the diverse activities indicated. In consequence, some rather ornate systems of management have been evolved, systems that have a tendency to extend beyond the narrower task of integration and include efforts to administer the technical aspects as well. The net result has been the development of systems of hierarchical decision-making which often include a full-time administrator for each 10 to 15 scientists or technicians.

C. UNIVERSITY AND GOVERNMENT LABORATORIES: SELECTED CASE HISTORIES

One may ask whether the same tendency to undertake group research with individuals of similarly diverse backgrounds, exists among the university and Government laboratories. This is an important consideration here because this writer's information is that these laboratories tend to be less managerially organized than industrial research groups. Again, there still prevails in the universities a strong tradition for scientists and engineers to have laboratories which are identified as their own. Notwithstanding these considerations, group efforts appear to exist here as are found among the industrial research laboratories. The following exemplary cases are extracted from several accounts of organized research furnished by scientists and engineers working in university and Government laboratories.

1. A breeder machine

This machine was designed in order to handle the problem of growing microorganisms under conditions of specified turbidity, by measurement of turbidity at 4-minute intervals.

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[14] Reeves, Management of Industrial Research, Esso Research & Engineering Co., at 7 (1953).
In 1940, Charles F. Kettering, of General Motors, affirmed that "group invention" was the method of the research organization which he directed. Hearings, Technology and Concentration of Economic Power, before the Temporary National Economic Committee, 76th Cong., 3d sess., pt. 30, at 16293 (1940-41). (Hereinafter referred to as TNEC hearings.)

PART I. CONDITIONS APPLICABLE TO THE PRODUCTION OF TECHNICAL KNOWLEDGE

CHAPTER II. THE NATURE OF RESEARCH ACTIVITY: THE PRODUCTION OF NEW TECHNOLOGY AS INQUIRY

Before one can evaluate research activity, its results and the role played by the patent system in respect thereto, it is necessary first to decide what kind of research activity we are talking about and what objectives and results we are concerned with. Research activity can be defined or classified in a variety of ways, depending upon what one is interested in.

For the purpose of patenting, for instance, a line must be drawn between research which involves the discovery of natural phenomena and that which involves the application of such knowledge, whether known before or not, to achieve new products or processes. In the operation of the American patent system, natural phenomena are not in themselves patentable. However, articles which embody the utilization of such knowledge, or statements of processes which may embody such knowledge, are subject to patent rights.

In another framework, such a distinction may be of little value, however practical and important it may be in operating a patent system. It does not, for example, afford an adequate basis for classifying the different types of work carried on in industrial, university, and government laboratories. For example, it is possible to formulate the criterion: The test of whether research is basic or applied depends on whether there is an immediate end in view to be served by the product of the research. By that test, given research activity, if oriented toward the production of particular products, would be called applied research; if directed to the production and publication of new knowledge as an end in itself, it would be classified as basic research.

Research work can be classified in still other ways. For example, does the work yield knowledge which is applicable to a wide range of phenomena?

Still another classification, one not generally used, but of especial significance in this study for reasons that will become apparent later, is in terms of the administrative setup for conducting research, to wit: Is the decision to do the work made by the investigator primarily responsible for carrying it out or by some other person, usually the supervisor in charge? This is a question of crucial import, more than it may seem offhand. Among scientists, there is wide agreement that the production of new science proceeds most advantageously where the investigator is free to follow his own bent in the choice of problems and the design of inquiry. When decision making as to research is largely in the hands of external managerial control, there is necessarily a retarding effect on the production of new knowledge, whether immediately evident or not. For external managerial control over the investigator impairs the process of free, imaginative ment, and pump design. Various occupations participated in the project. A surgeon contributed knowledge as to the importance of solving the problem of automatic regulation of blood pressure by infusion. He also contributed clinical procedures in the application of the machine. An experimental physiologist contributed knowledge on methods of blood-pressure measurement. Several drug companies furnished biological response data for particular drugs. These data were only partial and had to be further elaborated by the investigator. Physiologists and electrical engineers were active in carrying out experimental work with this machine on dogs in order to ascertain biological response to the drugs used. Electrical engineers contributed knowledge of servomechanism design and construction. An anesthesiologist contributed experience with another servomechanism designed in another institution for clinical use. About 25 vendors of electrical and mechanical components (small and large firms) contributed standard and special types of equipment for building this machine. Machine designers and machine shops carried out the detail of design of the units and executed the construction of special components. The laboratory of the National Institutes of Health at Bethesda, Md., supplied special designs of a pump for precision delivery of small quantities, especially suitable for medical-clinical applications. An experimental animal section of the research laboratory maintained animals for experimental work and prepared them for use, as well as contributing special knowledge on relevant animal physiology. A pharmacologist made available biological data on certain drugs that were used. An electrical engineer, physiologist, anesthesiologist, and animal technicians. all assisted in testing the equipment during development.

The design that was finally completed included several new aspects, including the mechanical design of a special pump, and development of a machine so designed as to be readily adaptable to related types of regulating problems.

5. Oil-well drilling

The following account, taken from a paper entitled "Trends in Industrial Research" by Dr. Clyde Williams [15] of Battelle Memorial Institute, exemplifies the team character of much of the research done at the Institute:

> In 1944–45, oil-well drillers in the Permian Basin oilfields of west Texas were having trouble with drill-pipe breakage. New strings of drill pipe would twist off far under the ground, necessitating expensive "fishing" operations and replacement. Drill pipe was costly, and labor and material losses were running into the millions. The American Association of Oilwell Drilling Contractors came to Battelle with the problem.
>
> After review of all the known factors, our coordinating committee sent a metallurgical engineer to the Permian Basin to examine broken drill pipe and talk to men in the field. He began shipping specimens of damaged pipe to Columbus, and in a few weeks metallurgists and metallographers were busy sectioning the specimens, and physicists and experts in materials engineering, aided by corrosion

[15] Battelle Technical Review, Battelle Memorial Institute, Columbus, Ohio (August–September 1955).

The process of inquiry is utilized at every hand by scientists and engineers. The product of this process is always technical knowledge, whether it be stated explicitly as a fact about particular phenomena or be utilized without explicit statement in the immediate work of formulating and testing the design of a particular product or process. In either case the production of the knowledge is the critical act.

For the purpose of this study the relevant research activity is defined and evaluated in terms of the new technical knowledge which it produces. This approach requires some comment. By this test, what is conventionally regarded as science is not differentiated from invention, since the production of new knowledge is the common feature in both.

This view of technical knowledge as a product in its own right, is held by many persons engaged in the direction of industrial research activity. In a recent address by Mr. E. D. Reeves, executive vice president of Esso Research & Engineering Co., for example, he indicated that—

> * * * the day is fast approaching when industrial research will produce technology as an industrial product in its own right. As this day approaches, industrial research will become more and more a separate industry creating an important raw material under highly competitive business conditions.[12]

Summary

In summary: In formulating the relation between the patent system and the production of new technology it is appropriate to fasten attention upon that feature of technical work that is common to all of this activity, namely, the process of producing new knowledge as such. With this approach, it is not necessary to differentiate between basic and applied science, i. e., the work of producing the knowledge and that of applying it to the design of particular things. For the difference between basic and applied research resides in the ends-in-view that accompany the work of inquiry, not in the nature of the work itself. The force of the formulation here adopted will become apparent in the chapters that follow.

It does not follow, of course, that the patent system itself may not suggest sharp and continuing differences between basic and applied research. Indeed, the patent system tends to emphasize only the immediate application of new knowledge, both in its requirements of patentability and in its rewards, and not the long-range values that one usually associates with basic research. To the extent that this differentiation persists in the patent system, but increasingly disappears in the actual conduct of research, however, it suggests a widening between what the patent system seeks to do and what it actually does.

Chapter III. Division of Labor and Interdependence in the Production of Technical Knowledge

In contrast to the one-man, lone wolf type of inquiry formally contemplated by the patent laws, the operation of industrial, govern-

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[12] Ninth Annual Conference on the Administration of Research, Northwestern University Technological Institute (Sept. 9, 1955). Mr. Reeves is not only an important industrial research executive in his own right; he is also the president of the Industrial Research Institute, a national organization of directors of industrial research laboratories.

nature. Equipment was designed to meet the necessary requirements for measuring variation in the very low concentration of tritium in various water samples.

The knowledge utilized here consisted of general background in physical chemistry and necessary background knowledge given in two published technical papers. One had appeared 20 years before the initiation of this work and had given estimates of basic design data for large-scale tritium production. The second paper gave design data for microscale operation of the same kind. The occupations represented in this experimental project included physical chemists, electrical-shop men for rewinding a motor to desired specifications, machinists for the design and fabrication of the machine, vendors of plastics with special electrical properties, and vendors of required mechanical components.

7. Hot-atom chemistry

This was a study on the hot-atom chemistry of the propylbromides. The problem here was to study the fate of the radioactive atom in order to learn what kind of chemical reactions it underwent between high-and low-energy states. It was found that these atoms form various compounds that were specified in the investigation. This investigation required taking the compound, for example, propylbromide, and exposing it to a neutron flux. Under these conditions, the propylbromide picks up neutrons, becomes radioactive, and undergoes various chemical reactions.

The knowledge used in this work included the design and operation of a cyclotron, high resolution distillation column technique, organic chemistry, physical chemistry, and physics. The cyclotron had been designed and built some 12–15 years earlier, though modified many times since then by the cyclotron crew. The occupations represented in this work included physical chemists, an electrical engineer and technicians for cyclotron operation, organic chemists for designing the distillation column, physicists, laboratory glassblowers, and a glassblowing firm to build special equipment required for the work.

8. Alcohol distillation

The problem here was to determine the effect of pressure on the composition of a class of chemical mixtures called aziotropes. In this investigation, it was determined that there was an optimum point in a chemical process for securing maximum alcohol in the product.

The knowledge utilized in this investigation included detailed chemical engineering experience in the petroleum-chemical side of the petroleum industry, design knowledge of isopropenol-water units, general chemical engineering, design of special pressure distillation equipment, and technique for construction of this equipment.

9. Flocculating agents

The problem here was to develop flocculating agents for phosphate slime. The materials previously used as such agents were high-cost synthetics, and the effort here was to develop a satisfactory starch derivative.

The knowledge utilized in this work included a long background of experimentation in starch derivatives, specialized work in colloid chemistry, and general knowledge in organic chemistry. The occupations represented in this work included physical chemists, technician

In a firm producing transportation equipment the engineering department responsible for research and development included the following occupations:

Electrical engineers	10
Mechanical engineers	2, 600
Commercial artists	270
Draftsmen and designers	2, 800
Medical staff	12
Photographers	10
Skilled technicians	2, 800

The staff of a large chemical industry laboratory included:

- Physical chemists
- Organic chemists
- Inorganic chemists
- Chemical engineers
- Physicists
- Mathematicians
- Laboratory technicians
- Instrument designers
- Machine shop personnel
- Laboratory equipment designers and constructors
- Librarians
- Translators
- Building and other service personnel

In one of the major laboratories maintained by this last-named firm, the scientific personnel are organized on a group basis. The composition of these groups, however, is deliberately arranged so as to include a diversity of personnel according to major technical competence. In the opinion of the directors of the laboratory, this systematic intermixing of scientists and engineers with diverse major skills has the effect of accelerating many research projects. This results from the ability to bring to bear a diversity of approaches to a given problem. In this same laboratory an effort is made to rotate the persons among groups.

Industrial research laboratories frequently make it a practice to retain staffs of consultants who visit periodically. These consultants include university professors in fields related to the primary work of the laboratory. Usually, the consultants visit the laboratory, conduct seminars for the staff, and consult with individual staff members. Industrial research directors regard this device as an important one for keeping their groups abreast of new knowledge developed in university laboratories, and for getting independent, critical opinions on the character of their own work.

B. GROUP WORK IN INDUSTRIAL RESEARCH LABORATORIES

The assignment of a given project to a group of persons is a common practice among industrial research laboratories. In one large laboratory which the writer visited, almost every project under way was being attacked by technicians working in groups. Typically, industrial research managers have been giving more and more emphasis to methods for integrating this group activity. Periodic meetings and seminars are employed in the effort to organize joint, multi-sided attacks on particular problems. One petroleum firm has proudly called attention to the fact that one of its research groups includes geophysicists, electronics engineers, and mathematicians.

Nor are these methods and policies of recent origin.

The director of the country's largest petroleum industry laboratory has given the following account of group organization for research activity in his field, even prior to World War II:

knowledge, and carry out the embodiment of these ideas in the form of new designs of things and processes.[16] It was under these conditions, prevalent at the close of the 18th century, that the American patent system was first formulated. Under these conditions, it is understandable that the category of "inventor" should have had real meaning in terms of the process of the production of technical knowledge and its application to the design of useful things.

E. THE PROBLEM FORMULATORS, THE INITIATORS, AND THE INVESTIGATORS

Under modern conditions of inquiry, however, it is generally not the investigator in a given laboratory who plays the role of an inventor and, by himself, contributes the activity required to achieve the experimental result. Instead, scientists and engineers now perform the creative roles of problem formulators, initiators, and investigators. Indeed, the initiator often not only formulates a particular problem, but also takes the lead in organizing the attack upon it.[17] Nevertheless, the necessary activity for the solution of the problem typically requires the participation of various persons drawn from various occupations. Under many modern conditions of inquiry, in short, it is unusual for a single investigator or any other person to play such a part in the conduct of inquiry as to justify singling him out as the sole person responsible for the result. Rather, he is only one of several whose individual activities were necessary for obtaining the final results in the investigations described above. No single line of activity was itself enough to produce the research result.

Granted this is not always the case. The conduct of creative work continues to display variability, and there unquestionably still exist many people doing creative technical work under conditions that resemble the historical pattern of the solo inventor. The fact remains that this is not the condition under which most scientists and engineers work today; nor does it represent the trend of modern research.

Formal specification or designation of creative responsibility is an ever-present problem in technical research. There is, for example, the matter of informal protocol that determines who is entitled to sign a research report. Usages vary among institutions, fields, and departments according to socially acceptable (though arbitrary) criteria for designating responsibility. But the relation of such designation to reality becomes more and more difficult. For, as the sciences have ramified, with all their detail of experimental technique, so has the individual investigator tended to become more of a specialist. And as this occurs, cooperation among persons and occupations in their efforts to attain results in inquiry becomes increasingly essential.[18]

[16] Ralph and Chandos Temple, The Temple Anecdotes—Invention and Discovery (London: Groombridge & Sons, 1865); Byrn, The Progress of Invention in the 19th Century (New York: Munn & Co., 1900).

[17] In many fields of science the crucial task of problem formulation has become, to a considerable extent, a group activity. This is plainly visible in the formal and informal discussions that occur during scientific meetings, laboratory bull sessions, lunch-hour talks and exchanges of notes with other investigators on experimental problems.

[18] Paralleling these characteristics of inquiry are the conventions that dictate what names shall appear as authors of technical papers. Differences in occupationally acceptable usages result in a varying correspondence between authorship designation and participation in the work of investigation. For example, in some laboratories the department head appears on papers as a participating author as a matter of course. Generally, the signators to a technical paper have indeed had a major hand in the work. It does not follow, however, that others may not have played a part, since it is not usual to record, except perhaps by a note of thanks, the various persons who may have contributed necessary parts of the work. Authorship listings on technical papers, in short, are not always good indicators of the characteristics of technical inquiry defined in this chapter.

The persons who contributed their skills to solving this problem included physicists, physical chemists, electrical engineers, machine shop workers, glass blowers, and vendors of electrical components.

After about a year of experimental work the problem was solved. A machine was designed which performed according to desired specifications. This machine was notable for the fact that it could be produced at a cost of a few hundred dollars whereas other equipment designed to yield the same effect had required outlays of from $6,000 to $10,000. The result was therefore of considerable interest insofar as it made possible substantial economies for investigators whose work required carefully regulated growth of microorganisms.

2. To determine experimentally the temperature distribution in a workpiece during metal cutting

The handling of this problem required prior knowledge in the following fields: physics, for flow of heat, radiation, and electrical properties; knowledge of metallurgy and metal cutting; surface chemistry; and mathematics. The occupations of the persons who contributed in the course of this project included physicists specializing in heat flow, a mechanical engineer who contributed to the experimental design and did preliminary calculations, and a mechanical engineer who specialized in the design and construction of apparatus. This project was also facilitated by a research scientist who had specialized in the design of apparatus and instruments.

3. The development of an ultramicrotome

A microtome is an instrument used for making very thin slices of things which can then be mounted for examination under the light of the electron-microscope. A Government laboratory had developed such an instrument for ultrathin sectioning based on mounting the specimen in a brass block. The brass block holding the specimen was first cooled in dry ice and then was allowed to warm at room temperature. As the block warmed, it expanded in size, thereby moving the specimen at right angle to the cutting edge while sections were cut. Another laboratory decided to attempt the design of a device which would allow for controlled heating of a metal specimen holder by a wire coiled about it. Such an instrument was built and gave a controlled linear advance, allowing for very fine sectioning.

The knowledge involved in the execution of this project included: instrumentation, physics, metallurgy, and insulation. The occupations of the persons who contributed directly to the solution of this problem included physicists, physical chemists, physiologists, machinists, and an electronics expert.

4. Automatic regulation of blood pressure

The problem here was to design a machine to regulate blood pressure by controlled infusion of a vasopressor drug. The main units required for this machine included a blood-pressure measuring unit, an electronic control unit, and a pump system. The purpose of this machine was to carry out by automatic means a function that had previously been done manually. Also, the machine was to carry this out on a continuous basis by means of feedback with measured blood pressure used to regulate the infusion of the drug into the blood stream.

The knowledge utilized for the development and design of this equipment included biological data, clinical procedures, automatic control system design, alternative ways of blood-pressure measure-to encourage continuity of employment, and thereby continue to make available to the employer the growing body of scientific and technical knowledge.

Compensation of technical and scientific employees on a piecework basis would be impracticable owing to the nature of the work and the difficulty of placing a value on their output. It is typically difficult to predict the number of man-hours and money outlay required to solve a given problem. Nor can formal budgeting systems overcome the problems of predicting man-hour requirements that stem from our limited knowledge of natural phenomena and ability to control them.

For these reasons and others, payment to technicians and scientists in industrial research laboratories is almost invariably on a salary basis. It is true that in some laboratories a moderate payment is made for filing patent memoranda, but this is unlikely to be more than a small fraction of the employee's annual salary.[22]

The level of incomes for scientists and engineers in industrial research is relatively high, averaging in the top 25 percent of the population. In a large industrial laboratory, for example, the starting salary for a chemist with a doctor of philosophy degree is $7,500 to $8,000. Salaries for research chemists (excluding administrative employees) range up to $15,000 or more.

B. PATENT ACTIVITY AND SALARY LEVELS

In industrial-research laboratories technicians are paid for work done whether their efforts yield successful results or not. Indeed, the larger laboratories make a special point of sustained salary payments over a long period, irrespective of whether the individual produces patentable results.

In some industrial laboratories annual bonuses are paid for outstanding contribution irrespective of whether they result in patents. Indeed, bonus payments based upon patent output are deemed unwise in some quarters. The director of one large laboratory, for example, objected to payments on this basis on the ground that a given patentable result emanates, not from a given individual, but from the overall strength of the organization which, in turn, has developed through the work of many people over many years. Accordingly, it is wrong, in his view, to single out a particular person for special recognition in the form of special payments. In this laboratory, instead, the management policy is to give recognition in the form of salary, rank, and public honors after considering many factors, of which the production of patentable inventions is only one. It is true that in this laboratory, money payments were once made on the basis of patents filed or research memoranda written. The result was a restraint on the flow of information in the laboratory. Many employees preferred to keep their findings secret until they could report them as whole units which would attract the attention of the laboratory director and thus result in a special bonus income. This kind of activity, the director empha-

[22] A payment of $100 for each case, or thereabouts, would be fairly typical.

chemists, electrical engineers, and geologists, were evolving a theory to account for the failures. Our teams of specialists quickly determined that drill-pipe failure was due to corrosion fatigue, induced by the peculiar drilling conditions of the area.

With the cause of failure determined, the problem was to find a way to prevent it. Since corrosion-resistant pipe was too costly, it was necessary to find ways to reduce or prevent corrosion and fatigue-crack formation without changing the steel. A number of approaches were suggested. We set chemists to work to find chemical inhibitors and develop plastic coatings for pipe interiors; nonferrous metallurgists and electrochemists, to develop metal-plating processes; mechanical engineers and physicists to devise operating procedures to reduce stress concentration during drilling; and electrical engineers and nondestructive inspection specialists to develop field procedures for revealing fatigue cracks before failures occur.

In the laboratory work, our engineers and physicists found that the operating lifetime of pipe specimens could be increased from 10 to 100 times by reducing the bending stresses. A practical field method for reducing bending stresses was worked out by our mechanical engineers. Our chemists and electrochemists, in the meantime, found that the addition of sodium chromate to the drilling fluid would increase pipe life as much as four times, and that plastic coatings and zinc plating would increase pipe life up to 150 times. Our electrical engineers came up with visual and magnetic field methods for detection of fatigue cracks in pipe before breakage, and our corrosion specialists showed that pipe life could be doubled by certain cleaning practices.

The final result of the study was a set of drilling-practice recommendations. These were made by Battelle within 10 months after the project was initiated. They were adopted by drilling contractors, and a little over a year after the research started, drill-string failure ceased to be a problem in the Permian Basin.

It is interesting to note that the research cost the drillers' association \$20,000. Despite the fact that many specialists were used, the total time charges of these men did not aggregate appreciably. By old-fashioned research methods, it is doubtful that one man could have even found the cause of the trouble within a lifetime, let alone provide a remedy. Against the \$20,000 that the project cost the drilling contractors, consider the economic benefits. Before the Battelle drilling practices were put into effect, individual contractors frequently lost as much as \$100,000 on a single drill hole. Gross annual losses ran into millions. The entire research costs were recovered by the contractors in less than 1 week of normal drilling operation.

6. Tritium in water

The problem of this investigation was the design and construction of a pilot plant for the enrichment of the natural tritium content of water. This was done as part of a larger investigation on tritium in reward) in determining the activity of the firm in sponsoring industrial research.[25] This will be analyzed in chapter VII.

Summary

In sum, scientists and engineers are now largely employees paid to exercise their occupational skills. This payment is on a time, not a unit of production, basis, and is substantially independent of patent taking. Much of the scientific work is done in nonprofit institutions, and here it is carried on with virtually no accompanying patenting activity.

Chapter V. The Cost of Producing Technical Knowledge

The general condition of interdependence in research is also revealed in the problems of determining the cost of producing technical knowledge in industrial firms and elsewhere. In universities and Government laboratories, where the production of technical knowledge is an end in itself, no attempt is made to assign a monetary value to given research results. In industrial firms, however, the conduct of the research is ancillary to the commercial exploitation of the knowledge that is produced. Accordingly, the question arises: What is the worth of given research? This in turn leads to the question: What does it cost?

Owing to the necessarily cooperative character of technical research and the payment of technicians apart from any particular output, the cost of carrying out technical research in industrial firms is necessarily treated largely as an overhead cost.[26]

For those in charge of industrial research, the problem of allocating overhead costs stems from the pressure of those in charge of general management to control the industrial research staff and expenditures. Thus, in their view, if the work on a project costs too much the project should be stopped. Cost accountants and industrial research managers have developed a range of proposals for keeping track of industrial research costs. These proposals involve methods, largely arbitrary in nature for categorizing and allocating the various outlays made in the conduct of technical research activity. The cost accounting proposals range from no track-keeping at all of the activities of individuals, to elaborate systems of controls.[27]

Arbitrariness in estimating the cost of production of new knowledge extends to the problem of evaluating the worth of patents. Clearly, there are alternative possible ways of assigning money value to a patent. These include estimates of the production cost of particular knowledge; income from the exclusive use of patented knowledge; valuation of a patent on the basis of Patent Office fees paid, plus special fees such as bonuses to the contributing technicians; estimates of the market worth of given patents if offered for sale; and finally,

[25] It has been suggested to this writer that the holding of patents may have some prestige effect among technical men. In this writer's experience there is no indication of the weight of this factor, if any.

[26] "Overhead" refers to a relationship between the input and output of a given production unit or firm. Thus, the salary of an accountant is a direct cost in an accounting firm but an overhead cost when the payment for accounting is made by a machine shop. An "overhead" relationship exists when a given output does not vary with or is not clearly traceable to the input.

[27] See, for example, the discussion in Cost Budgeting and Economics of Industrial Research, Proceedings of the First Annual Conference of Industrial Research, at 224 (New York: Kings Crown Press, Columbia University, 1951); also Morris, The Philosophy of Research Budgeting and Cost Control, in Coordination, Control, and Financing of Industrial Research, at 186 ff., 153 ff., and 221–228 (New York: Kings Crown Press, Columbia University, 1955); Taylor, Control of Research Costs, The Accountant, at 272–273 (April 1956).

assistants, suppliers of chemical equipment, and machine-shop men who constructed equipment to the design of the technician assistants.

10. Thyroid gland

This was an investigation of the thyroid gland and iodine economy of the human body. The experimental work involved a problem in the use of tracers, which included problems in experimental control, experimental techniques, as well as problems of warranted inference from the observations that were made.

The occupations of persons who contributed to this experiment included the endocrinologist, who was the principal investigator; a mathematician and a mathematical statistician brought in to counsel on the design of experiments and on problems of warranted inference from the experimental data; laboratory technicians, who assisted in conducting the experiments; and statistical computers used to handle the resulting data. A group of human volunteers made themselves available for experimental observations under hospital dietary control.

* * * * * * *

In each of these 10 foregoing cases, 1 or 2 persons were primarily responsible for initiating the project and were formally responsible for the work. In each case, however, it was necessary, for the execution of the work, to bring to bear the knowledge and the skills of a variety of persons. Under these conditions, the creative work of designing experiments, evaluating results, considering the merits of alternative methods, and the like, takes on a cooperative character.

The episodes described above are not unique. On the contrary, it is commonplace for persons other than the principal investigators to contribute significant knowledge or intuitive perception to the conduct of particular investigations. During the course of research work, one typically does not even attempt to record the detailed nature of contributions from various persons. In one case described to this writer, a principal investigator on a research project found that he and his colleague could not even identify the person who had contributed one of the critical ideas in the work, owing to the fact that continuous informal exchanges of ideas were a regular feature in that laboratory.

Indeed, the enumeration of occupations that participated in the projects described above is an understatement of the variety of persons who contributed necessary activity for the execution of the work. For each of these projects involved, not only the efforts of individual researchers, but also the use of considerable laboratory equipment. This equipment was, in turn, the embodiment of a wide variety of technical knowledge, both of scientific predecessors and of contemporaries. The collaborative nature of those responsible for the equipment used is underlined by the fact that in some laboratories special attention is given to equipment sections whose operations make possible rapid attack on problems.

D. THE MEANING OF "INVENTION"

These exemplary cases of the organization and execution of particular inquiries have direct bearing on the meaning of "inventor." It may have once been the case that single persons, operating substantially by themselves, were able to formulate ideas, produce new the primary investing in a given product line. In this respect the holding of patents can be an instrumental device in the competitive struggle.

The managements interviewed in the course of this investigation reported uniformly that the major factor in the operation of their research laboratories and in research decisions has been the extent to which new knowledge gave advantages to their own firm, not the extent to which it resulted in income from patent licenses. Indeed, fees from the latter accounted for not more than 10 percent of annual outlays for industrial research.[36]

While the opportunity to obtain patents does not appear to have a controlling effect upon the intensity of industrial research activity, it can significantly affect its timing and location. Research on industrial machinery, for example, is typically carried out by the users or by the conventional vendors of such equipment.

Finally, patents are widely used as instrumental devices in competition among firms. Aspects of this use of patents have been recorded in court records, in the hearings and reports of various governmental bodies, and in other studies of the patent system.[37]

It should be emphasized, however, that the patent is only one of many devices and techniques that have been used in interfirm competition.[38]

5. Industrial research and the promotion of science and technology

There can be no doubt that many of the results emerging from industrial research laboratories are relevant to the promotion of science and the useful arts. It is nevertheless the case that the advancement of knowledge as an end in itself is not an objective of industrial research activity. Possibilities for industrial firms to facilitate the promotion of science and technology by the expenditure of large resources have existed for a long time. The scale of present industrial research outlays and their growth is traceable not to the search for knowledge in itself but to the fact that the production of new technical knowledge has become an increasingly important competitive weapon in the struggle for position in industry.

6. Research facilities as assets

Owing to the critical role played by industrial research organizations in interfirm competition, the very existence of such research organizations becomes an important factor in determining the relative standing of firms. Industrial firms now need engineers and scientists to serve as a reservoir of knowledge for directing the development of new products and new production methods. As a result, the very possession of the industrial research laboratory means possession of the means for producing new knowledge that feeds into product and process development technique. It should be noted that these values in an industrial research facility exist quite independently of whether

[36] It is true that some firms make a specialty of developing patent rights and licensing them at fees which, in the aggregate, are a substantial portion of the firm's total income. This practice, however, was not found among the large industrial research establishments examined during this inquiry, and does not appear to be prevalent.

[37] See, e. g., Vaughan, The United States Patent System (Norman: University of Oklahoma Press, 1956), which contains an excellent bibliography.

[38] Burns, The Decline of Competition (New York: McGraw-Hill Book Co., 1936).

It is true that our language has retained words like inventor, but its meaning is sustained by colloquial and formal usage. However stable the language usage over many decades, there has been, in contrast, a marked evolution in the characteristics of science and its application to the technical arts. The conditions of technical creativity, of inventing, have changed even though the term has not. Today the production of technical knowledge typically results from the integrated application of division of labor, at least in a great many of the most important fields, and not from isolated, individual effort.

Summary

In summary: Modern scientific and engineering research is increasingly characterized by the integrated application of the work of various specialists. The resulting conditions of interdependence in inquiry render the concept of the inventor obsolete to a considerable extent. The functions once embodied in the solo inventors who dominated the technical scene are now more often than not performed by various persons working in a cooperative group effort. To the extent that this is true, the traditional patent system, with its emphasis upon the protection and reward of the inventor, necessarily becomes less attuned to the purpose that it was set up to perform.

Chapter IV. Producers of Technical Knowledge and Their Payment

One of the assumptions underlying the patent system is that the income obtained through its special property rights is significant, and thereby sustains the patent holder in his creative endeavors. Accordingly, the question is posed: What are the primary sources of compensation for the scientists and engineers who man the network of laboratories in industrial firms, in universities, in government, and in private foundations of various types?[19]

A century ago engineers were substantially self-employed. Such people and mechanically skilled, self-employed artisans undoubtedly comprised the largest number of inventors at that time. While they certainly drew upon prior knowledge in the various sciences and arts, these people did their creative work substantially as solo efforts. By the middle of the 20th century, however, scientific and technical creative activity has specialized into full occupations that are mainly manned by employees.[20]

Today, the scientific and engineering occupations are overwhelmingly employed occupations, with only a small proportion self-employed. For example, by 1930, only 4.3 percent of the total number of engineers in the United States were engaged as independent consulting engineers, that is, as self-employed persons.[21]

A. Salary Policy

Scientific and technical employees are paid for carrying out a class of work particular to their occupation, not on the basis of output. Salary policies for technical-research employees are designed primarily

[19] The reward to the industrial employer who hires research personnel is discussed in ch. VI, below.
[20] Anderson and Davidson, Occupational Trends in the United States, at 515, 516, 546, 547 (Stanford: Stanford University Press, 1940).
[21] Id. at 550.

PART II. THE USE OF TECHNICAL KNOWLEDGE AS PROPERTY

Chapter VII. Implications for Business

What are the implications from the business and competitive standpoint of a firm taking out patents? To answer this, one must first examine the extent of patenting activity and ascertain whether it has kept pace with the expansion of business-sponsored research and development. Secondly, the use of patents as a weapon in interfirm competition will be reviewed. Finally to be examined is the question whether extensive patent holdings are a necessary condition for successful competition among firms.

A. PATENT ACTIVITY AND BUSINESS-SPONSORED RESEARCH

Among persons who are active in the patent field, there is substantial agreement that the opportunity to obtain patents has been a potent incentive for research outlays by industrial firms. If this assumption is valid, it supports the contention that patenting is an important factor in industrial research. But do the facts support the assertion? One way to find out is to examine the relation between patenting and research activities. The relation between research and patent activity can be approached in two ways, to wit, in aggregate terms and through the detailed records of particular firms.

For the period 1941–54 there are reliable estimates of the total number of research scientists and engineers in the United States. These data can be compared with the number of patents granted on inventions by the Patent Office. The data of table 1 show a dramatic growth in the number of scientists and engineers from 87,000 in 1941 to 194,000 in 1954, an increase of 120 percent. During the same period the number of patents issued shows a marked fall. Even if allowance is made for administrative problems of the Patent Office and other factors, the larger picture that emerges is plain enough. There has been no growth in the number of patents taken on inventions that matches the increased number of scientists and engineers in the industrial and other research laboratories in the country.[40]

[40] One may properly ask whether it takes more manpower and costs more to make a given invention today than it used to? The data available here do not give a direct answer to this question. The several tables shown in this chapter do show, however, that the differences in rates of development between technical employment (and budgets) and patenting are large, both in the long run (1900–1954) and during shorter periods (1941–54, 1950–55, 1940–55, and 1942–54). It seems unlikely that changes in the state and circumstances of science and production technology during these shorter periods have been sufficiently great to explain the lag in patenting activity shown by these statistics. The writer is advised that there is no indication of any steady upgrading, over the decades, in the Patent Office standards of invention which would account for the reduction in patenting—at least to an extent beyond that which would balance the increased competency of technicians. Whitmore, What's Got Into the Office Lately? 29 J.P.O.S. 869 (1947); cf. Hearings before the Senate Subcommittee on Patents, Trademarks, and Copyrights, 84th Cong., 1st sess., at 72–95 (October 10–12, 1955).

sized, did not make for the sort of teamwork needed in carrying out research within a complicated technology.[23]

A similar view was expressed in 1940 by Charles F. Kettering, in charge of research for General Motors, when he emphasized the importance of avoiding methods of compensation which would give an incentive to individuality in research performance at the expense of "team play." [24]

C. PAYMENTS TO CONSULTANTS

The industrial research laboratories visited by this writer retain consultants who are paid an annual retainer fee for advice and consultation on the conduct of research. Some laboratories also give research grants to professors who function as their consultants. In the view of one research director, it is a good idea to support the professors in this way. Sometimes, he indicated, the answer to one question from a consultant pays for many years of consultant fees. Nevertheless, the total outlay for such purposes is only a minor portion of most industrial-research budgets. Such retainers, like the salaries paid regular employees, represent payments for the consultant's time, not payments for the production of bits of knowledge.

D. PAYMENTS IN UNIVERSITIES, FOUNDATIONS, AND OTHER NONPROFIT INSTITUTIONS

In universities and other nonprofit institutions, rewards to scientists, and engineers engaged in research activity typically are unrelated to patents. Rather, payment takes the form of an annual salary which is substantially independent of the production of particular technical knowledge. Indeed, substantial work in science is done by persons who receive no income at all, namely, graduate students working toward advanced degrees. These not only produce new knowledge but do so at a time when they may actually be paying fees for the privilege of working under the supervision of the faculty and utilizing the facilities of a university.

E. PATENTS AS A SOURCE OF INCOME FOR SCIENTISTS

The 17-year exclusive rights given to an inventor by a patent may very well have been, at one time, a principal source of income to the inventor. Under current conditions, however, the primary income of scientists and engineers comes in the form of a salary that is independent of the worth of the particular knowledge that is produced, whether patented or not. Accordingly, the patent rights tend to be separate from payment to scientists. To be sure, the taking of patents does have a role in the business practices of industrial firms and it remains to be seen whether patenting is a necessary condition (as a

[23] In January 1954 the vice president in charge of research at the Bell Telephone Laboratories wrote:
"We know also that all inventing is a competitive race among individuals all over the world. It is this competitive element which leads to the danger in special awards or rewards to inventors when taken outside the framework of their total contribution as compared with the total contributions of their coworkers. 'Each man for himself and the devil take the hindmost' may be a good motto for stimulating some kinds of effort but it has no place in the joint endeavor of a technical group of individuals pooling matched and interlocking talents and skills. It is an interesting and perhaps significant fact that approximately 1 out of every 4 (23.3 percent) of the inventions made at laboratories during the past 25 years involved 2 or more inventors." (Bown, Inventing and Patenting at Bell Laboratories, Bell Laboratories Record, at 6 (January 1954.))
See, also, note 18, supra, on the relation between formal authorship and actual division of labor in the production of technical knowledge.

[24] TNEC hearings, supra, note 14, at 16310.

TABLE 2.—*The number of patents granted for inventions in relation to the growth of engineers and scientists*

	(1) Scientists and engineers [1]	(2) Index of growth of scientists and engineers	(3) Patents granted for inventions [2]	(4) Index of growth of patents granted for inventions	(5) Index of relative growth of patenting in relation to scientists and engineers col. [(4) ÷ col. (2) × 100]
1900	42,000	100	24,660	100	100
1910	86,000	220	35,168	142	65
1920	135,000	320	37,164	150	47
1930	227,000	540	45,243	183	34
1940	310,000	740	42,333	171	23
1950	573,000	1,360	43,072	175	13
1954	691,000	1,640	33,872	137	8

[1] National Science Foundation, Scientific Personnel Resources, at 9 (1955).
[2] Department of Commerce, Historical Statistics of the United States, 1789–1945, at 312 (1949); Statistical Abstract of the United States, 1955, at 505 (1955).

When one turns from the general to the specific and examines the detailed data of the firms that were sampled for this investigation, the same picture is presented, differing only in degree. Detailed statistics covering major firms in the electronics, chemicals, transportation, and petroleum industries are presented in tables 3 to 6.

Table 3 shows the data for firm A during the period 1950–55. There was a threefold increase in the number of scientists and engineers engaged in research and development, and the number of engineers engaged in manufacturing (i. e., concerned with the design of production facilities and related activity) increased in about the same degree. During this period there was also an increase in the number of patent applications, but in contrast to the almost fourfold increase in the number of engineers and scientists employed in research, these increased by only two-thirds; in other words, at less than half the rate that research activity increased.

In firm B (table 4) the available data show the development from 1940 to 1955. Although detailed and exact statistics were not available, it appeared that the number of patent applications on inventions made during this period fluctuated between 300 and 350 each year. During this same period, however, the number of scientists and engineers in the laboratories increased by about 40 percent.

The data for firm C are more complete, insofar as they show both the patents issued for selected years and patent applications filed. By both criteria, patenting activity showed a manifest decline over the period 1940–55, while the number of research scientists and engineers in the firm increased about 50 percent; again, showing patent activity increasing at less than half the rate that research activity increased.

In the case of firm D, the picture is different. Here, there was a doubling in the total research and development staff from 1940 to 1955 which was accompanied by a proportionate, and in some years even greater, increase in patent activity. The management of this firm includes a large patent staff, with an elaborate file of patents, both domestic and foreign, that relate to its sphere of activities. This estimates of the income that can be gained from licensing a given patent.[28]

Some corporations carry patents as only nominal assets, e. g., $1.

Summary

In summary: There are no established and accepted ways of evaluating the money worth of patents, either in terms of cost or in terms of market value. The cost aspect is of greatest interest here. The difficulty in evaluating the cost of producing a given patent stems from the character of research. Where the activities of many persons must be integrated as necessary conditions for the production of given knowledge there are no known methods for obtaining an objective measure of the total worth of the inputs required to produce a given result.

Chapter VI. Determinants of the Production of Technical Knowledge

The role of patents in relation to the promotion of research may be clarified by looking at them in another perspective. What are the decisive factors that determine how, and to what extent, manpower and other resources shall be applied to scientific and technical inquiry? For this discussion two different areas of research activity must be separately examined, to wit, by nonprofit institutions and by industrial firms.

A. Research by Nonprofit Institutions

In universities and other nonprofit laboratories, most scientific work is carried out for its own sake. Additions to knowledge about natural phenomena are regarded as ends in themselves and their expression is normally achieved through the free publication of the results of inquiry. In the universities, the control over the kind of work to be done and the selection of problems to be attacked, rests primarily in the hands of the responsible investigators, subject, of course, to the general limitations applicable to the particular institution or department. Under these conditions the pace of work is substantially controlled by the resources available for staff and supporting equipment, buildings and the like, and, of course, the skill and enthusiasm of the research personnel.

To scientists and technicians operating in nonprofit institutions, in other words, the main end-in-view in doing the work is the work itself. No ulterior justification is required to justify the appropriateness of particular inquiry.

The successful solving of important scientific problems, of course, has important occupational effects, e. g., in establishing the relative status of the individual investigators, but it does not have much bearing, in and of itself, upon the question whether the particular line of research is deemed more or less important than some other line.

B. Research by Industrial Firms

In industrial firms a variety of channels may be followed in deciding how much research will be done and in what fields. There appears

[28] For recent discussion of the problems involved in assessing the monetary worth of patents, see Rudy' Patent Asset Evaluation, 37 J. P. O. S. 571 (1955).

TABLE 6.—*Firm D—Patenting, and employment in research and development*

Year	Total research and development staff	Patents issued
1940	1,301	132
1945	1,990	228
1950	1,860	359
1955	2,528	247

NOTE.—The original data have been altered by a constant factor to avoid disclosure of source.

In these tables relating to patent activity and research personnel, the data reflect the employment of the professional scientific staff. They do not take into consideration the outlays in plant and equipment that accompany the employment of larger scientific staffs. A body of data are available for firm E which show, for 1941–54, both total research expense and the number of patents granted. The data have been cast in the form of index numbers as shown in figure 1. The outlays for 1941 are taken as the base period. During the period reviewed the number of employees in research and development doubled and major additions were made to the plant and its equipment. Total research expenses show sustained increase until, by 1954, they were nearly five times the prewar level. Yet, over the same period the number of patents granted, while fluctuating somewhat from year to year, never exceeded by more than 60 percent the number granted in 1941.[42]

Altogether, the data for these particular firms indicate that major expansions have been undertaken in research activity in order to meet business requirements. The same cannot be said of the intensity of patenting. Apparently, the research requirements of these firms have been satisfactorily met without a proportional increase in patenting. Such net results are hardly to be expected if, as is sometimes suggested, patenting is the primary or even a major incentive in determining industrial research outlays. On the contrary, the data here indicate that, within the business structure here under study, patenting is not necessarily closely related to industrial research activity.

[42] The relative amount of time of industrial research management devoted to patent matters provides no conclusive indication, although it has some bearing upon the importance attached to patenting by industrial research managements. The sampling of firms made in the course of this investigation indicates that, on the average, the amount of time devoted by research directors to supervision of patent affairs varies substantially among firms, from less than 5 percent to about 25 percent of their working hours. This variation seems to be in direct relation to the total number of patents taken and the importance assigned to patenting in company policy.

3. Variation in research activity among countries

Most industrial countries possess patent systems. If the operation of a patent system were the controlling factor in determining the outlay for industrial research, we should expect to find substantial similarity in research activity among fully industrialized countries. That, however, is not the case as an examination of comparable data for England and the United States shows. Thus, in 1951 a sample study of 278 industrial firms in England disclosed that research and development outlays amounted to 1.49 percent of net sales; whereas, in the United States (1,934 firms), the ratio was 2 percent during the same period.[32]

Another way of viewing relative outlays for technical research is the number of engineers and scientists. In England in 1951 there were 3.7 engineers and scientists per thousand of the population. For 1954 the United States figure was 5.2. Thus, assuming no major change from 1951 to 1954, the number of such persons per thousand of the population was 40 percent greater in the United States than in Great Britain.[33] More recent investigations of United States and British research activity disclose similar patterns.[34]

The manifestly larger relative outlay for scientific and engineering work in the United States as against Great Britain does not appear to be reasonably attributable to patents since both countries possess a patent system. It would seem, in short, that the operation of a patent system could not have been a controlling factor in determining industrial research activity.[35]

4. The patent as an instrument of competition

From 1941 to 1954 there was a greater than twofold expansion in the number of research scientists and engineers in the United States. During the same period the number of patents annually granted actually declined. Even if allowance is made for the fact of delays in the Patent Office, there is no escaping the fact that patent activity has not increased to the same extent as has the intensity of research activity. This suggests to this writer that patent-taking does not in itself appear to be a crucial factor in the operation of industrial research facilities.

Although patents may not be a controlling factor in determining the production of technical knowledge, they do appear to be a factor in determining investment decisions, at least according to information on company policies given to the writer. The holding of particular patents, for instance, may determine which firm in an industry does

[32] Federation of British Industries, Research and Development in British Industry, at 10 (London: 1952), Bureau of Labor Statistics, Scientific Research and Development in American Industry, at 26 (1953).

[33] National Science Foundation, Scientific Personnel Resources (1955). General Registrar Office, Census 1951, Great Britain, One Percent Sample, Tables Part I at 32–41, 42. (London: Her Majesty's Stationery Office, 1952).

[34] Rudd, Expenditure on Scientific Research and Technical Development in Britain and America (Department of Scientific and Industrial Research, Intelligence Division), presented at section F of the British Association, September 4, 1956.

[35] Rather, this difference can probably be accounted for in terms of some major differences in the operation of the industrial firms of the respective countries. Perhaps the distinction lies in the dramatically different pressures on the managements of industrial firms in the two countries. In England, until after World War II the home markets for industrial and consumer products were relatively stagnant and heavily cartelized, while the Empire markets were relatively protected areas. In the United States, on the other hand, the managements of industrial firms have been competing for position in a large, expanding home market for both industrial and consumer goods. See the analyses in Brady, Crisis in Britain (Berkeley: University of California Press, 1950), especially chapters 1 and 13. The relative intensity of research activity among American industrial firms may be traceable to the growing pattern whereby a firm strives for competitive advantage through product and cost competition.

Another factor that has a major effect on management's industrial research outlays is the pressure for developing productivity-increasing production methods in order to counter the growth in the relative cost of labor. See Melman, Dynamic Factors in Industrial Productivity (New York: John Wiley, 1956).

There is another side to this functioning of patents. Insofar as one firm may mark off a given area, competitive firms may be stimulated to develop something new or different. Accordingly, a substantial part of the product development activity in many companies consists of researches directed to designing products and processes which will enable the researcher to circumvent patents already held by other firms. One industrial research director indicated that they keep an active watch on the patents taken by other firms, in order to block or circumvent developments that may originate elsewhere. Tactics of this type, of course, are ideally suited for large industrial organizations. Only units of substantial size can marshal the arrays of diversified talent needed for this type of interfirm combat.

3. Patents for trading and income purposes

The use of patents as instruments for trading among firms ranges from bargaining over single patents to intricate arrangements of a broad cross-licensing character. Certain of the larger firms in the United States, for example, prefer to arrange extensive cross-licensing agreements with their counterparts in other countries. In this way, as they see it, the patents of both are usable both ways and substantial benefits accrue to each party. Cross-licensing on a large scale is also sometimes undertaken between firms in separate industries. The practicality of such arrangements stems from the pervasive relevance of given technical knowledge. For example, new knowledge brought to light in the laboratories of a chemical industry firm, can be important to firms in the machinery, electrical goods, or textile industries.

Trading in patents also occurs on a single patent basis. This may occur even where firms are in a competitive position in the sense that product lines and the underlying technical knowledge may overlap. Where this occurs patent claims or areas of patent claims also overlap. At such times a stock of patents is regarded as a useful resource for trading or bargaining among firms.

Trading or licensing may also be undertaken for the primary purpose of obtaining income. On the whole, however, it appears that the major industrial firms have not developed their patent holdings with the aim of securing major incomes from licensing. One leading firm, for example, with research outlays of $25 million a year receives an annual income from several hundred licensees that nevertheless amounts to only 10 to 15 percent of the annual research expense. These license fees tend, in some cases, to be merely nominal in amount. The writer's industrial informants emphasized repeatedly that the conduct of research, and the pursuit of patent holding, were primarily designed to protect and expand the competitive position of the firm—rather than to secure income from licensing fees.[44]

4. Safeguarding returns on research investments

In the view of the research managers consulted the holding of patents also serves the function of safeguarding the investment made in research by means of the exclusive property rights vested in the patent holder for a period of 17 years. They urged repeatedly that a shorter period of patent holding, say, 5 years, would be unsuitable from this standpoint.

[44] See note 3, supra.

patents are taken out or not. The operation of industrial research facilities thus becomes, in itself, a form of insurance for protecting or advancing the relative position of the firm in interfirm competition.[39]

Summary

In summary: The discussion in the preceding chapters has indicated that the leading characteristic of the production of technical knowledge under modern conditions is the division of labor, and the necessary integration of work that must accompany it. These modern characteristics of the production of technical knowledge are reflected in the manner of payment of engineers and scientists. This is primarily on a salary basis, that does not vary with output per unit of time.

These features of research activity are also reflected in the problems of determining the cost of performing particular research activity. Such costs are usually overhead in character, and therefore are not necessarily traceable to particular units of research output. This overhead character of the industrial research cost structure stems from the integrated character of much of the creative activity that is involved.

Finally, it is noted that the factors influencing industrial research activity are the changing circumstances of interfirm competition, much more than the availability of patents. Likewise, the conduct of research in universities and other nonbusiness groups is largely independent of patent considerations, since in the nonbusiness laboratories knowledge is produced for its own sake and the search for knowledge irrespective of its commercial and industrial value, is a primary criterion in selecting research projects.

Against this background of conditions surrounding modern technical research, this inquiry now turns to an evaluation of such research and technical knowledge in terms of its use as property. This is the major theme of part II.

[39] On this matter it is instructive to review the testimony given in 1940 by Charles F. Kettering, vice president in charge of research at General Motors Corp. TNEC hearings, supra, note 14, at 16292-16317.

"* * * They must have spent millions on the symposia they conducted just to educate us and get us in the business. After all, patents give only the bare essentials," commented the chief executive of another pioneer in the transistor field. "They gave us the know-how in the many meetings they conducted." [45]

This writer pursued this problem with the managements of several industrial research laboratories. The question asked was: "Would it be possible to operate the * * * process with the information given in the network of patents which cover this process?" The answers were "No" even in the cases where patent coverage, in the opinion of competent persons, was unusually comprehensive. Often, much information of an unpatentable nature is required to operate satisfactorily a given process or to produce a given product, including, among other things, detailed information accumulated in the operation of pilot plants and the initial periods of full-scale production. In the case of new products, it includes the relevant experience accumulated in the early period of production, during which many minor modifications may be made in the design or in the production process. The accumulation of this know-how is as necessary for the economic operation of a process, or production of a satisfactory product, as is the information given in the patent.

Such data are typically unpublished, and remain as confidential information in the hands of the technicians and operating staffs of manufacturing plants. They may be partially recorded in the form of operating or manufacturing design specifications. In many firms a sustained effort is made to retain exclusive access to such knowledge and systematic security measures are applied, to prevent its disclosure to outsiders[46]— measures that may prove quite effectual in those instances where it is not possible to ascertain manufacturing method details from the finished product itself. Owing to the important role of such nonpatented knowledge, a patent license typically includes as well the know-how on building and operating the necessary plant facilities, and the cost of furnishing such information is included in the license fee.

D. BUSINESS CRITERIA APPLIED TO THE PRODUCTION OF TECHNICAL KNOWLEDGE

Business management has been enlarging its outlays for research and development at the rate of about 10 percent a year, and has thereby been extending its sphere of managerial control into the area of the production of new knowledge. By 1952, the total national expenditure for scientific and engineering research amounted to $3.75 billions, of which $2.5 billions was for work in private industrial establishments.[47]

For business as a whole the significance of this expansion lies in the fact that the criteria of the business process are thereby applied to the

[45] New York Times, January 25, 1956.

[46] The fences, guards, identification badges, and security checks that surround industrial laboratories are evidence of these security measures.

[47] U. S. Bureau of Labor Statistics, Scientific Research and Development in American Industry, at 1 (1953). Current estimates place the figures at more than $5 billion, of which almost 50 percent comes from Government and most of the remainder from industry itself, with a minor contribution (in dollars) emanating from universities and foundations. New York Times, January 2, 1957, at 49.

TABLE I.—*The number of patents granted for inventions in relation to the growth of research scientists and engineers*

	Research scientists and engineers [1]	Index of growth of research scientists and engineers	Patents granted for inventions [2]	Index of growth of patents granted for inventions
1941	87,000	100	41,184	100
1947	125,000	144	20,149	49
1954	194,000	220	33,872	82

[1] Department of Defense, Office of the Secretary of Defense (Research and Development), The Growth of Scientific Research and Development, at 12 (1953).
[2] Department of Commerce, Historical Statistics of the United States, 1789–1945, at 312 (1949); Statistical Abstract of the United States, 1954, at 520 (1954); id., 1955, at 505 (1955).

Even more striking is the lag that appears when one examines technological effort generally. Activity in patenting as compared with change in the total number of scientists and engineers, not just those engaged in research and development work, is shown by table 2. As this table shows, from 1900 to 1954 there occurred a massive expansion in the number of scientists and engineers from 42,000 to 691,000, an increase of 1,600 percent. In contrast, over this same period the largest increase shown in any given year in the number of patents granted was only 83 percent over the number granted in 1900 and in most years the increase was even smaller than this. The relationship between the growth of the number of scientists and engineers and the number of patents granted is reflected in the fifth column of table 2, by dividing the index of patent growth by the index showing the growth in scientists and engineers. The data show a steady and persistent decline from 1900 to date in patenting as compared to overall scientific and engineering employment. In other words, activity in taking out patents has lagged increasingly behind the total activity in science and engineering, as indicated in the growth of the total population of scientists and engineers, until today it is less than one-tenth of what it would be had it kept pace.[41]

[41] It may be suggested that the growth in Government-contracted research work during recent years may involve the employment of technical men on work that is not conducive to patenting by the contractor firm, since the patents would be Government-owned. This would not, however, explain the decline shown in table 2 which shows relative patenting activity since 1900. Nor does it explain the situation among the individual firms, as shown in tables 3 to 6 and in figure 1. Of the firms, only one is very active in Government-contracted research and development and the data for this firm have been adjusted to exclude the Government-contract research staff.

Summary

In summary: On the basis of the evidence at hand it is clear that substantial extension of research under business control has been carried out without parallel expansion in the number of patents taken. That is understandable since the determinants of industrial research activity, as shown in chapter VI, are not dependent upon the availability of the patenting privilege. At the same time the tactical use of patents has continued as an important instrument in interfirm competition. Large firms, especially, have enjoyed advantages in their utilization of the patent system. This tactical use of patents as a control over the use of knowledge has been supplemented by management-operated security systems designed to restrict access to technical knowledge. Finally, it is indicated that while patents do play a role in interfirm competition, their aggressive manipulation has not been a necessary condition for business success, since firms which have pursued a "low pressure" patent policy have also enjoyed such success.

Chapter VIII. Implications for the Universities

The universities are the principal area for the production of science. The role of the universities as mainsprings of science remains substantially unaltered despite the growth of specialized research foundations, and Government laboratories. Moreover, the universities are the crucial means for training new scientists and engineers.

Since universities themselves, as well as individual faculty members, may be the holders of patents, it is relevant to inquire as to the bearing of such patent holding upon the progress of science. What has been the direction of effect of patent holding upon the research and teaching functions of the universities?

Many universities have established formal policies whereby the control of patents by the university may be so arranged as to yield an income both to the school and the faculty patent holder.[51] Where university administrations have pressed commercial exploitation of patents stemming from the researches of the faculty, this has been done in an effort to obtain needed funds for the university's work. From this standpoint, one might expect to find especial enthusiasm for such use of patents among schools with limited budgets, among departments working in fields that require unusually large funds for apparatus and the like, and in schools with less developed traditions of academic freedom and less concern for the traditional basic objectives of higher education. Conversely, those institutions with the opposite characteristics should presumably be less interested and active in obtaining patents and commercially exploiting them.

To check this, selected universities and departments in the latter category were examined; institutions, in other words, that were presumably in a relatively strong position to withstand pressure for the commercialization of university research. Sample laboratories for study were sought on the following basis: Each should be a unit of some importance in its scientific field. It should be located at a major university where the total budget and annual sums available for scientific work are appreciable. The laboratory should be an integral part of the university and not a separated unit attached to

[51] See note 53, infra.

is not sufficient to explain the difference in patenting activity, however, since the same holds true for the other sampled firms. One clue to the performance of firm D may be found in its policies as to what constitutes appropriate material for patenting. Senior executives of the industrial research facility indicated that an effort is made to secure patent coverage in as much detail as is permissible within the framework of patent practice, and not to limit oneself to key patents. Indeed, the management of these laboratories advised this writer that competent outsiders had characterized the firm's patent coverage on one process as the most elaborate they had ever encountered. It is also noteworthy that in this firm, an employee is rewarded for patent applications filed by receiving a special bonus of $100 for each such application attributable to him.

TABLE 3.—*Firm A—Patenting, and employment of scientists and engineers*

	Employment of scientists and engineers		Applications for patents on inventions
	In research and development	In manufacturing	
1950	520	554	63
1955	2,020	1,826	105

NOTE.—The original data have been altered by a constant factor to avoid disclcsure of source.

TABLE 4.—*Firm B—Patenting, and employment of scientists and engineers in research and development*

Year	Employment of scientists and engineers	Patent applications on inventions
1940	1,863	300-350
1945	2,101	300-350
1950	2,022	300-350
1955	2,658	300-350

NOTE.—The original data have been altered by a constant factor to avoid discl sure of source.

TABLE 5.—*Firm C—Patenting, and employment of scientists and engineers in research*

Year	Employment of scientists and engineers	Patents issued	Patent applications filed
1940	212	222	274
1941		160	212
1945	258	171	193
1950	302	196	165
1955	328	[1] 89	191

[1] 1956, 1st quarter, 39.

NOTE.—The original data have been altered by a constant factor to avoid disclosure of source.

The intensity of patent-directed work has varied among laboratories. The departments that have been most patent conscious have been held in poor esteem by graduate students. In these laboratories the department heads have attempted to direct the work of graduate students along conventional lines rather than to encourage new departures in basic research. Thesis work for the fulfillment of advanced degree requirements has been designed in part, to extend and protect previous patents and pressure is put on graduate students to direct their thesis work into those channels where patenting possibilities exist.

Patent aspects play an important part in faculty attitudes. One faculty member who had assigned his patents to an industrial firm for exploitation was subjected to severe criticism, and may well have suffered thereby with respect to academic preferment. There have also been conflicts among faculty members on the issue of who was entitled to be designated the inventor in particular patent applications. One professor was censured by his colleagues for declaring that some of them were placing monetary considerations above the requirements of scientific productiveness.

A tendency away from frontier research has led to a gradual decline in the quality of work done and of the students produced by the departments concerned.

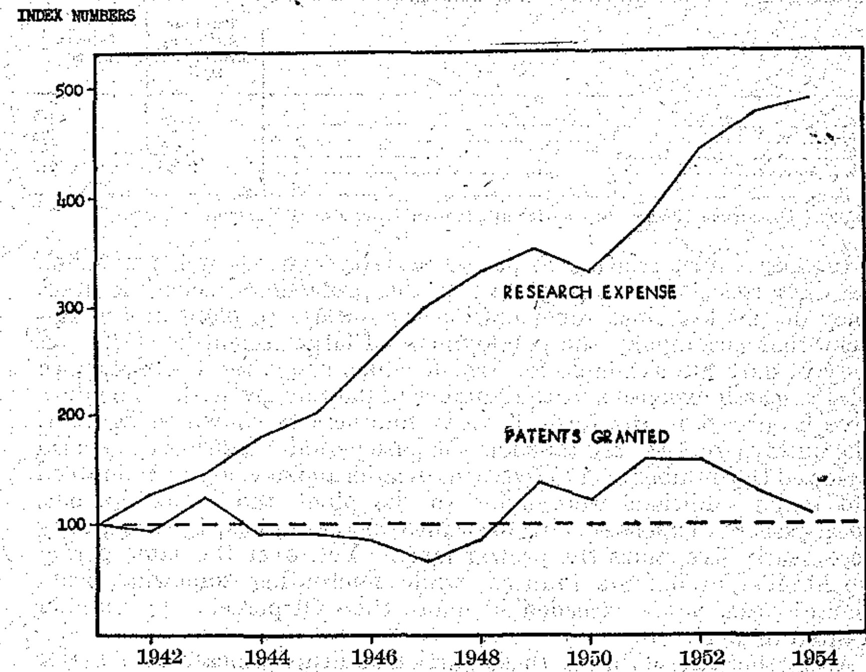
Case 3. Individual patent emphasis by faculty and researchers.—In this university there has been little officially sponsored pursuit of patenting as a source of income for the university. Individual professors, however, have obtained patents on research conducted by them, including projects in which graduate students have participated.

At examinations upon dissertations produced by students toward fulfillment of graduate degree requirements, the following has occurred on some occasions: In response to questions by examiners, the student has replied that he preferred not to disclose the relevant information since it was involved in a patent claim. Reaction to such events has been mixed. Sometimes the examiner abandoned the line of inquiry. At other times, one or more of the examiners present have insisted on full answers to all relevant questions without regard to problems of patent claims.

How representative are these cases? In view of the small number cited here, one might, of course, suggest that the situations disclosed were unique and not characteristic of such institutions. It is significant, however, that, without naming names, the writer described the cases here reported to a few knowledgeable colleagues in several universities and invited their guesses as to the identity of the institutions involved. Some 15 different schools were named as being the ones in question. This suggests that, in the estimate of those familiar with university practices, at least, the episodes are exemplary rather than atypical. This conforms to impressions received by the writer on the basis of partial information similar to that described above which has been available to him with respect to many other laboratories in other universities, although it was not possible to pursue inquiry as to detailed conditions in these places. To be sure, a rather more extensive examination of such practices than could be carried out by this writer would be needed to establish the full facts of the case.

It remains to examine the implications of such conditions in universities and their impact upon the progress of science and the useful arts.

FIGURE 1.—FIRM E—PATENTS GRANTED AND RESEARCH EXPENSE, 1941–54



B. TACTICAL USE OF PATENTS

While the total number of patents issued has not kept pace with the expansion of business-directed technical research, the tactical use of patents in the interests of interfirm competition has been a sustained feature of management practice.[43] Patents have served (1) as guides to areas of investment, (2) as markers for research fields, (3) as the basis for trades among companies, (4) as devices to facilitate financial returns on research investments, and (5) as bases for fraternization with the nonindustrial scientific and technical community. These will be discussed in order.

1. Patents as a guide to areas of investment

In various ways, patent ownership plays an important rôle in decisions on new plant investment, especially as that concerns investment in new products. The holding of patents, backed by experienced legal staffs, is regarded as providing protection against infringement-suits by other firms and thus assures greater "freedom to use" particular knowledge.

2. Patents as markers of research fields

In conversations with managers of industrial research units, the use of patents as devices for fencing off research fields, was repeatedly stressed. In order to serve this function, a blanketing operation is called for whereby several dimensions of an area of research are staked out through extensive patent coverage.

[43] See, for example, Vaughan, The United States Patent System (Norman: The University of Oklahoma Press, 1956).

3. Restrictions on publication

Free publication of research results is an essential part of the process of inquiry, for it facilitates independent verification of findings. When the search for patentable results is a guiding consideration, strict secrecy concerning work in progress and limitations on publication become necessary devices to serve the patenting process.[52] Indeed, limitations on publication have become a standard aspect of much research effort on business, military, and political problems. Under modern conditions of great interdependence in the conduct of inquiry, measures that curtail the flow of knowledge necessarily hinder the promotion of science and technology.

4. Effects on students

The experience of students in patent-oriented laboratories tends to be exactly contrary to the desirable training for developing good scientists. Their attention is in danger of being directed to defined problems of limited scope, instead of being encouraged to range freely and imaginatively in the search for ways of pushing back the frontiers of knowledge. The close direction of their work that is likely to characterize research in which patents play a part, gives no experience in the exercise of their own initiative in formulating problems and designing investigations. And finally, the example of secretiveness and restriction on publication is no training for efficient participation in the production of knowledge under conditions that require cooperation among investigators.

Taken as a whole and in the light of the four factors just discussed, the practice of patenting in universities is important both for the effects directly traceable to it, and as one aspect of the use of extra-science criteria to guide inquiry. In the judgment of this writer, the weight of evidence indicates that, on balance, the use of such criteria and the practices that accompany them are damaging to the scientific productiveness of the universities. The unique contribution that universities can make inevitably suffers whenever knowledge as an end in itself is replaced by other criteria and methods, no matter how publicly acceptable these latter might be and however useful they may be as guides for nonuniversity institutions.

Paralleling these weakening effects, there is the expansion of research facilities and staffs at universities that may be owing to the funds derived from patent licensing, although, on the whole, university income from this source has not been very great.[53] Substantial enlargement of staffs, buildings, and laboratory facilities has undoubtedly occurred at some universities as a result of patent operations. Can it be said, however, that this enlargement in the scale of research activity outweighs the adverse qualitative effects of managerialism and commercialism? The question must remain unanswered, in this paper at least. This writer does not know of any

[52] It is true that the act of patenting itself represents a form of publication. It is a limited form of publication, however, both as to the scope of what is reported and the timing of publication. See ch. VII, above. For the efficient pursuit of inquiry, the timing of public disclosure of knowledge is often very important and delay in publication may have seriously adverse effects in terms of the overall contribution and when it occurs. The timelag in the patent field must be evaluated with this in mind. Patents take over 3 years from date of application before they issue, on the average, and it is possible to extend the time still further if one is so disposed and uses a little ingenuity. Such a disposition sometimes exists, since delay is often to the advantage of the patentee inasmuch as the patent runs for 17 years from the date of issuance. Thus, since "issuance" is a form of publication, there is a built-in feature of the United States patent system which tends to delay, and in that sense limit, publication.

[53] Palmer, Patents and Nonprofit Research, Study No. 6, Senate Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, 85th Cong., 1st sess., at 59–61 (1957).

One large firm put it this way in estimating the average time required to move from the initiation of a new technical idea to the profitable marketing of a product: Fundamental research normally has required about 5 years, followed by a 2-year period of commercial development which, in their experience, is being reduced by more concentrated effort; thereafter, the manufacturing department development for a new product requires about 5 years; following these stages, an indefinite number of years are required before the new plants begin to yield a profit on the investment.

On the basis of these estimates, the time required for getting a return on the initial research is not less than 12 years, and may well run the full 17 years or more. In these circumstances, the 17-year period of patent right may be quite inadequate from the standpoint of getting a return on research investment, even if patents are taken late in the development cycle. The fact is, however, that the 17-year period is often significant, not necessarily as it applies to a single patent, but rather as it applies to an accumulation of concurrent and successive patents on a given product or process. When a basic patent is supplemented by additional improvement patents, the practical effect may be to extend the period of effective patent protection well beyond the 17 years, notwithstanding the expiration of the original patent.

5. Fraternization with the scientific community

Once a bit of knowledge has been embodied in a patent, industrial research managers advised this writer that their scientists and engineers can be free to discuss this knowledge, at least within the limits of the disclosure contained in the patent.

Industrial research managers place great importance upon the ability of their staff to fraternize, as they put it, with the general scientific and technical community. This contemplates more than just appearing at the meetings of technical societies, for example, and absorbing the knowledge set forth there. Rather, the position of the staff is enhanced if members can appear and make affirmative contributions in the form of technical papers. Their ability to do this is facilitated by the fact that patents have already been applied for, thereby staking out a property right in a given area of knowledge.

The significance of this type of participation for the promotion of science and technology will be discussed further in chapter IX.

C. TECHNICAL KNOWLEDGE WITHHELD FROM PATENTING, AND ITS SIGNIFICANCE

Restrictions on patentability sometimes limit the information relevant to a given design or process that is embodied in the patent. In other instances, however, managements prefer to withhold certain knowledge from public view, in any form, regardless of patentability. Included in this category is that considerable body of information relating to production detail, referred to as know-how.

An example of the problems posed by this practice is found in the recent A. T. & T.-Western Electric antitrust case.

Following the announcement of a consent decree which settled that suit, certain licensees were interviewed by the New York Times. It reported their comments on the activity of A. T. & T. as follows:

promising their main research interests or changing their research fields in order to secure them.

President Dodds, of Princeton University, has called attention to the dangers of these developments in terms of their impact upon universities and their responsibilities for basic research and the production of technical knowledge:

> With the abundance of project research money currently available, we are in danger of succumbing to a new disease for which no antibiotic drug has been discovered; namely, "projectitis." Projectitis is an unhappy addiction to limited objectives, perhaps at the very moment at which the individual should be broadening his own comprehension and deepening his knowledge of his discipline, with freedom for roving speculation in an atmosphere unencumbered by the pressures of problem-solving commitments to external agencies.
>
> Concentration upon organized team projects which have limited objectives and are circumscribed by a production schedule may operate to deflect interest from truly basic scholarship which it is the duty of universities to carry on. The universities must not fail in this broad function, for no other agency in society will assume it if they do.[56]

The trend toward Government-supported-and-directed research in the universities has its counterpart in industry-supported research. Indeed, so extensive have the various forms of industrial research and engineering consulting at universities become, that it has received the formal attention of the Federal Bureau of Internal Revenue. Thus, the current Internal Revenue Code and regulations thereunder, classify as taxable those activities on university premises which are of a conventional applied research character and being carried out for business purposes.[57]

Summary

In summary: Pressures for aggressive patenting start in universities in the interest of securing additional funds for research and teaching. However, the managerial characteristics of the directed research efforts that tend to flow from this policy and are undertaken toward this end, abridge the free pursuit of knowledge as an end in itself. In turn, these methods tend to have a weakening effect upon the functioning of universities as centers for scientific work. Thus, in the long run, pressures for patenting and similiar efforts, if sustained, could exhaust the resources of the university that are essential for the training of new investigators and the pursuit of knowledge as an end in itself.

[56] Quoted in: Sponsored Research Policy of Colleges and Institutions, at 78 (Washington, D. C.: American Council on Education, 1954).

[57] The regulation reads as follows:

"For the purpose of this section the term 'research' does not include the activities of a type ordinarily carried out as an incident to commercial or industrial operation, for example, the ordinary testing or inspection of materials or products or the designing or construction of equipment, buildings, etc. The term 'fundamental research' does not include research carried on for the primary purpose of commercial or industrial application." Income tax regulations No. 118, Internal Revenue Code, Federal Register, at p. 6147 (1953).

selection of research projects, as well as in deciding what is to be published and the timing of publication.[48] These aspects of technical research are closely related to the central concern of this study, namely, the promotion of science, and therefore will be treated in chapter IX, below.

E. CONTROL OF TECHNICAL KNOWLEDGE AS A FACTOR OPERATING TO THE ADVANTAGE OF LARGE FIRMS

Only firms of relatively large size can afford the sustained outlays involved in operating major research facilities. Moreover, only the larger firms are able to undertake the kinds of many-sided research into particular problems which yield an interlocking network of patents covering a given subject matter. The advantage of this latter is emphasized by the managers of industrial research who indicate that, from the standpoint of patent protection, what is most valuable is a rounded development and the portfolio of patents that pertains to it. But such patent coverage of a many-sided character is possible only as a consequence of a major research effort and this can be undertaken only by laboratories of size.[49]

Given this situation, the formal ability to apply for patent rights does not necessarily provide advantages to different-size firms in direct proportion to their size. In other words, the small firm with 10 percent of the total patent coverage possessed by a competing large firm with respect to a given process, may not have the equivalent of 10 percent of the control over that process, but something considerably less. In the light of these considerations, the control of extensive research laboratories has come to be regarded as a critical business asset in its own right.[50]

F. PATENT POLICIES AND SUCCESS IN BUSINESS COMPETITION

The evidence made available during the course of this investigation disclosed that there is no necessary correspondence between aggressive patent policies and success by business criteria. All of the firms whose activities were examined for this investigation were firms of large size, each eminently successful in its own field by every test of business success. Yet there is substantial variation among them in the importance attached to patent practice. Some firms use patents extensively and do well. Others virtually disregard patent rights as a possible asset and competitive weapon and also do well. In short, while patents can be and are used as instruments of business competition, aggressive patenting policies do not appear to have been necessary conditions for the attainment of business leadership in the industries studied.

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[48] Ralph Bown, vice president in charge of the Bell Telephone Laboratories, wrote in the Bell Laboratories Record, January 1954, "What we publish we decide in the interest of the Bell System as a whole." This statement is important, not for its novelty, but for its emphasis upon the business considerations underlying the policy decisions—in contrast to other possible criteria for publication, such as the promotion of science and the useful arts.

[49] See note 11, supra. Also, see the discussion on Patents as Markers of Research Fields, sec. B (2), supra.

[50] Large firms have other types of advantage as well, in the production of technical knowledge. In fields where instrumentatior is important, for example, there is a cumulative effect from gathering, over the years, special types of measuring equipment, expertly designed and constructed. Such an accumulation of material vastly facilitates many experimental operations. This type of advantage is uniquely possible for the larger laboratories in a given field.

any event, they form a part of the growing body of technical knowledge. That, however, does not detract from the inhibiting effect that managerial methods of decision-making inevitably have upon the conduct of research.

When one stands on the threshold of new knowledge there can be no guidance for the investigator from any received doctrine or directive. What is required at this juncture is the free, uninhibited, intelligent imagination of the investigator. These become the critical elements in the work of problem formulation, experiment, and inference by which new technical knowledge is produced.

To be sure, this may be less true, at least in some areas, with respect to technical research of an applied character. Here, the end in view as well as methods can often be specified without harm or hindrance to research performance or end result.

But even here, such supervision may have the same wet-blanket effect that it has upon basic research. One of the striking observations consistently made to the writer in the course of this study involved the variation in productivity among sections of industrial research laboratories. In each major laboratory visited, the research director commented that the less applied section of the laboratory had been the most productive of new ideas and patents. In one major laboratory, for example, 70 percent of the patent applications come regularly from the section containing only 20 percent of the staff, whose problems were broadly defined, thereby leaving room for initiative on the part of the investigator.

Employees in industrial research laboratories cannot escape the decision making of management in these matters, for the operation of these laboratories is on a hierarchical basis, with the management operating along business lines and being guided by business considerations. This attitude ultimately seeps down to the research staff itself. Thus, in one laboratory the management has specified to the scientists and engineers that they may devote 10 percent of their employed time to any problem they like, apart from the projects to which they are assigned by the management. They have not taken advantage of this opportunity.

B. CRITERIA FOR DECISIONS ON RESEARCH PROJECTS

For industrial research managers, the central criteria for the selection of research projects are the requirements of the competitive position of the firm. These considerations are controlling, however removed the particular research area may seem to be from immediate application to products or processes. Such calculations of business tactical requirements, and the usages that surround them, do not make a scientist a better scientist. Indeed, such criteria necessarily inhibit the quality of free-wheeling imagination which is a necessary condition for the broad pursuit of science.

The rewards for the conforming scientist include promotions, increases in salary, and public honors. A technician who fails to accord with the management's requirements must necessarily suffer in these respects, as long as he works within the framework of a business-directed research laboratory.

the university only through a contractual tie. Its field of science should preferably be one not requiring unusually costly equipment, such as the large machines needed for some studies in physics. It should be located in a large, well established university with long tradition and reputation as a center of research in science and engineering. Finally, it should include persons of recognized status in their fields.

A. SOME CASE STUDIES

It was possible to obtain reliable accounts of the impact of active patent policies from investigators in three laboratories which met these qualifications.

Case 1. Profit-oriented research through collaboration with private firms.—This is a department in a university of recognized standing. It is supported primarily by patent royalties. The staff includes men who have achieved distinction in science.

An industrial firm was assigned rights to exploit patents based on work done at the university by various staff members. Income to the university from the sale of products covered by these patents is used in large part to support the operation of the laboratories.

Scientists employed in these laboratories are repeatedly reminded by the director that there are certain lines of work in which the laboratories have a special stake, owing to the development of patent rights in these fields. The development of further patentable material is urged as a necessary step for protecting and enhancing the financial position of the department.

As one might expect under these conditions, a substantial part of the work done is oriented toward product development. This results from two factors: (1) Decisions on the selection of problems are made by those charged with carrying out these policies and not by the investigators who do the work, and (2) the lines of research stressed by these policymakers are of a type normally pushed by private firms in the given field with the object of developing patentable products.

As in industrial firms, laboratory employees are required to sign a release assigning all rights to patentable developments to the university.

Some staff members keep close track of the earnings record from patentable products originating from work at their laboratory; and informal discussions of these matters and of the movements of securities prices in the patent holding field, are recurring features of working hours. Graduate students attached to these laboratories also have become actively interested in these extraneous features.

Owing to sustained pressure from the director, the climate for non-income-producing research is not especially favorable, and scientists in this laboratory who wish to devote their efforts in some part to such research informed me that they have felt that they must resort to subterfuge.

Case 2. Patent-oriented research among faculty and graduate students.—In these university-located laboratories patent taking has been actively pursued. Patents are usually assigned to a special unit for commercial management. The bulk of the funds obtained from commercial exploitation has been used to promote studies in various fields of science and to finance laboratory construction and equipment.

was possible to determine the average elapsed time between the "private" publication of particular new knowledge, i. e., its circulation in the internal, classified reports of the firm, and its "open" publication, i. e., the receipt of papers for publication in various scientific and technical journals. The research director in this case estimated that for a group of papers representing the output during a recent year, a period of 4 to 5 years elapsed between "private" and "open" publication.[60] Publication decisions were arrived at in the following way: Drafts of technical reports were circulated to various departments of the firm. If the director of a department found something of potential interest to him, he so indicated and the paper was withheld from "open" publication. As a result, some things were published rather quickly while others were not published for years, according to the dictates of company policy.

In this firm, even after it is concluded that publication is consistent with the interest of a given department, the published papers often do not include details of "know-how" which are essential for the utilization (in production) of the knowledge given in the technical paper. This is often true of papers appearing in the scientific journals, whether of industrial or nonindustrial origin. In nonindustrial scientific circles, however, the gaps are easily filled, since such information, as a rule, is made freely available on request by the investigator concerned. In any event, the unpublished technical details frequently comprise a body of knowledge that is conventionally known among specialists in a field.

In the case of technicians in industrial research laboratories, the situation is different. They are not free, as a rule, to divulge the details of their experimental work. It is well known, for example, that in some scientific fields the employees of industrial firms appear at scientific and technical meetings primarily to take away with them whatever they can learn from the others, especially the university people, and contribute little or nothing in return.

This view that "it is more blessed to receive than to give" is also evidenced in other ways. The practices of industrial research laboratories in obtaining knowledge, for example, are often in marked contrast to their publication policies. In one of the laboratories whose publication activities have been characterized above, a large library receives regularly several hundred periodicals which it abstracts for the benefit of the concern but not for general publication. This abstracting service has been operated because the existing services do not cover all the fields of interest to the laboratory. Furthermore, the abstracting service operated by the firm operates more expeditiously than the standard abstracting services available to all libraries, operating with a delay time of only 1 to 2 weeks in contrast to the latter's delay time of about 2 months.

There is a clear contrast here between policy for the intake of knowledge that justifies the buying of 6 to 7 weeks of time, even at considerable expense, as against the publication policy with its average delay time of 4 to 5 years. One laboratory director indicated that, "like a university," he "felt an obligation to put good science into the technical journals." He indicated, however, that while publication

[60] This estimate of elapsed time between production of knowledge and "open" publication is all the more significant when it is recognized that it is based on papers already published and excludes from consideration papers that have never been presented for publication at all. Eventual inclusion of these, when and if they are finally published, would considerably extend the elapsed time.

B. EMPHASIS UPON PATENTING WEAKENS THE UNIVERSITIES AS SCIENTIFIC CENTERS

Insofar as concern with patenting spreads through the universities, they become correspondingly less valuable as producers of new knowledge. This results from: (1) the tendency to select problems for research on the basis of whether they will lead to patentable inventions, not whether they will add to the store of knowledge as an end in itself; (2) the introduction of managerial decision making over investigators; (3) restrictions on publication; and finally, (4) adverse effects on the students themselves. These effects on the characteristics of university-located research are independent of the availability of larger budgets, better buildings, and more staff.

1. *Extrascience criteria*

It is possible to select problems for investigation with an eye to business, military, or political criteria. Concededly, substantial social importance is often attached to such problems. Nevertheless, when these, or any other particularized criteria, are made the yardsticks for inquiry, the appropriate scope for inquiry is thereby restricted. In other words, when the scope of the problems is limited by the use of particularized criteria, paths that might yield new knowledge are closed off to the investigator.

In contrast, the search for technical knowledge as an end in itself knows no such boundaries. When guided by this criterion, continuing inquiry leads to the unfolding of still further areas of knowledge. This, in turn, opens the way for many detailed technological applications that may have been completely unanticipated and unthought of when the search started.

2. *Managerial decision making*

Many kinds of technical work can be carried out under managerial forms of control. This is especially so where the desired results can be specified in detail, and where the methods to be used are routine. In the production of new knowledge, however, such outside control and orderly blueprinting of procedures rarely works. In the very nature of the case, the results in the search for new knowledge cannot be specified or ordered. Rather, these are likely to rest in the intuitive judgment of the investigator himself, in tentative hypotheses which he develops and which, in turn, frequently require him to devise new experimental methods in order to test their validity.

In the main, managerial forms of decision making can have no constructive role in such a creative process, where the procedures that yield a productive result cannot be specified in advance, or by persons who are removed from the work itself. (See ch. II.) They can only inhibit the free play of imagination and methods that are necessary here, and limit the number of imaginative minds that may be applied to the formulation and solution of problems. Once competent investigators are reduced to the role of simply carrying out a supervisor's orders, then there are fewer people who can follow the imaginative bent that is necessary in the genuine pursuit of new knowledge.

The net result is almost bound to be a restriction on the output of new knowledge.

At first appearance, the attempt to answer this type of question may seem to be somewhat speculative since, indeed, a patent system does exist. Nevertheless, in this writer's judgment, enough is known about the impact of patenting to permit a useful answer to this question.

This chapter attempts to cope with this question under the following headings: "What would be the effect on science if no patent rights could be obtained upon technical knowledge"; by implication from that, "What would be the effect on the engineering technologies"; "How would the scope of industrial research be affected"; "What are the possible limitations likely to accrue from removing property rights to technical knowledge?"

A. EFFECT ON SCIENCE, TECHNOLOGY, AND RESEARCH IN NONINDUSTRIAL LABORATORIES

The effect upon science and technology of making technical knowledge generally and freely available, or vice versa, is determined primarily by the conditions under which scientific research is carried out.

The production of new knowledge is carried out, primarily, in nonprofit institutions where the problems of property rights in knowledge are of secondary importance. This is the case in the universities, private foundations, and in many Government laboratories devoted to research in the sciences. In such institutions, the principal reasons for carrying out research in the basic sciences would continue to operate whether there were a patent system or not. The present sources of support for such work would, presumably, continue. The necessary scientific personnel would continue to be available, in this writer's judgment, provided salaries, social prestige, and other conditions of work made these occupations reasonably attractive. There already exists a tradition among scientists that the production of new technical knowledge is a sufficient end in itself. Therefore, the absence of opportunity for obtaining patents on this knowledge would not adversely affect the primary occupational incentive of the great mass of scientists for producing new knowledge.

In certain respects, the elimination of patents might actually facilitate research. For example, university and other scientists would be relieved of the pressure that now exists upon some of them to produce patentable results and, as a consequence, would have more freedom to work on problems of their choice. Furthermore, insofar as opportunities for university scientists to obtain patents were removed, the effect would be to remove the pressures toward secrecy that can result from emphasis upon patenting and which inevitably dampen free communication.

Secrecy in technical work has been a problem for research managers in industrial firms, as well. Recently, Dr. Jules D. Porsche, manager of the central research department, research division, Armour Co., delivered an address in which he indicated that—

> Characteristic of the environment which has a markedly dampening effect on the creative thought is secrecy. Within a company, a barrier to the communication of both information and ideas can be a very serious obstacle to the effec-

way of gaging the possible effect of larger numbers and greater facilities as a counterweight to acts that dull the spirit of imaginative inquiry.

In the estimate of this writer, it is not likely that administrative devices in the universities, designed to ameliorate the adverse effects from patenting, would serve to alter the force of this analysis. For the effects described above take their essential direction from the very nature of the attempt to use knowledge as property.

It must be emphasized that the adverse effects noted above are not the results explicitly sought by university administrations and are independent of their formal patenting policies. Thus, an examination of formal policy statements for universities, including the three wherein arose the cases cited above, gives no indication of the type of effects which have been reviewed here.[54] On the contrary, the various university policy statements establish the broad and apparently worthy goals and policies to be pursued in the course of dealing with patents that grow out of university-located research.

Rather, the effects noted above, to the extent that they occur, have occurred as impersonal, derived effects which come about because faculty members have been pressed to produce income for their university (or for themselves) by taking patents on the results of their research. There is nothing to indicate that the weakening effects described here have been deliberately sought or preferred by the persons concerned. Quite the contrary. The evidence shows that the pursuit of patenting has been undertaken as a means for solving problems of limited funds for scientific and engineering work at universities. The fact remains, however, that once the policy is adopted, the forces described above which push in the direction of defeating the ultimate objectives of expanded and improved basic research, begin to work. The incongruity between means and ends may well finally lead to an effective distortion of the original, explicit, and ordinarily worthy end-in-view.

C. EMPHASIS ON PATENTING IS ONLY ONE EXAMPLE OF PRESSURES UPON UNIVERSITIES TO STRESS "APPLIED" RESEARCH

The pursuit of research in universities for purposes of patenting is, in fact, only one of a number of pressures currently put upon universities to shift to applied research as against the production of knowledge for its own sake. Especially since the Second World War, Government has been pushing universities to carry out research activities relating to its many engineering and development problems.[55] It is true that the universities themselves, pressed to finance university budgets from limited resources, welcomed the availability of these funds. Many of the university professors have been equally receptive to such grants, even to the extent, in some cases, of com-

[54] A. M. Palmer has prepared several publications on patent policies in universities for the National Research Council (Washington, D. C.). The most recent of these are: Nonprofit Research and Patent Organization (1955); and University Patent Policies and Practices (1952); see also, Patents and Nonprofit Research (1957), op. cit. supra, note 53.

[55] From 1941 to 1955, universities and other nonprofit institutions increased their annual expenditures for research and development from $40 million to $420 million. Of this $380 million increase, about $60 million came from the nonprofit institutions themselves. The rest came mainly from Government. See: Department of Defense, Office of the Secretary of Defense (Research and Development), The Growth of Scientific Research and Development, at 10, 11 (1953), including 1953–55 data added by the publishing agency; National Science Foundation, Federal Funds for Science, pt. V. The Federal Research and Development Budget, Fiscal Years 1955, 1956, and 1957, at 38–43 (1956). These data show funds from major Federal agencies to universities.

The second consideration suggested here was that research that would not benefit the firm would be abandoned, in the absence of a patent system. The fact is, however, that the only research now carried on must meet the test of benefiting the firm, either as new product development or in the form of lower production costs. Would such a firm discontinue industrial research activity if it could not utilize one of the benefits that it presently receives, to wit, the powers available through the patent system? To say that it would, implies that it would abandon product and process (cost) competition. This is tantamount to saying that such firms would abandon their business character, since interfirm competition for control of markets and for differential profitmaking are essential parts of the business process. In this writer's opinion such a development is unlikely.

(3) Another firm visited by the writer replied as follows: (a) If there were no patents, then publications from this laboratory would be curtailed. (b) Also, the scope of the work would be expanded. (c) Research would be concentrated on things that could be kept secret; for example, various production details. The writer notes the following with respect to the first point. Present publication policy in this firm has been severely limited by the requirements of patenting and by its policy of retaining control of knowledge, insofar as possible, in order to further the firm's exclusivity with respect to commercial application. As a result, publication of technical results by researchers in this firm typically occurs, if at all, several years after the findings have been made. Further, the patent claims made by this firm, although constituting a form of publication, typically do not disclose sufficient detail of the patented knowledge to make it usable in production by competitors. Here, as in many other firms, it was emphasized to the writer, the information disclosed in the patent often does not enable another person to operate a plant, since there is lacking that vast store of operating detail (know-how) which is as necessary for purposes of plant operation as the information disclosed in patents.

(4) In another firm the opinion was that, in the absence of a patent system, three things would happen: (a) There would be no opportunity to trade in patent rights with other firms. At the present time, with a large stockpile of patents held, the firm has access to about four times as many patents as they own by means of cross-licensing agreements. Without patenting, it was said, the management would become secretive with respect to the work done in the laboratory and would tend to rely primarily on the knowledge generated in its own research establishment. This, they felt, would mean getting along with a restricted range of knowledge. (b) Also, without patent protection new findings could not be published and thereby the quality of the laboratory staff would suffer, since the firm would be unable to attract competent scientists if there were no possibility for them to improve their general professional status through free presentation of papers in technical journals and at meetings of technical societies. (c) In the absence of a patent system, the relative position of the firm in its industry would be unchanged.

The foregoing comments suggest that one of the uniform reactions to be expected from abrogation of the patent system, would be an increasing resort to secrecy. As several pointed out, however, secrecy is often difficult, if not impossible, to maintain for any length of time.

CHAPTER IX. IMPLICATIONS FOR THE PROGRESS OF SCIENCE AND TECHNOLOGY

The operation of a patent system and active participation in patenting by industrial managements have profound implications for the progress of science and technology. Two-thirds of the total national expenditures for research and development in science and engineering are controlled by industrial managements.[58] The pursuit of patents, to a varying but considerable extent, affects who decides on research, the criteria for decision-making, and publication policy. These are key aspects of the functioning of the scientific and technical occupations.

In this analysis, particular attention is given to the effects of these factors upon developments in the field of basic science, for the store of broadly relevant knowledge that stems from this type of research provides the basis for subsequent extensive technological applications. Apart from the tendencies in universities discussed in chapter VIII (whose full ramification is unknown), the university faculties pursue inquiry without being influenced or deflected by patenting criteria. To the managers of industrial research laboratories, however, patenting considerations are important. Their activity is therefore the focus of this chapter.

A. WHO DECIDES ON RESEARCH?

In one of the well-managed laboratories visited by this writer, decisions on research projects are made in the following manner. The order to carry out a project is issued by a management steering committee in a short directive of a few paragraphs. This committee originates some research projects within itself. It also depends on initiative from the professional staff for proposing research programs. After the steering committee has made a decision the work is assigned to a research man. In the words of the laboratory director, the researcher decides on daily and weekly procedure, methods, and the like. An effort is made within this framework to assign projects to men who are themselves particularly interested in the subject matter, as indicated, for example, by their research proposals.

A modified form of control operates to retain internalized regulation of research project selection. Thus, the investigators are told that they are free to select research projects, but are advised that, in a broad sense, they are expected to keep the interests of the firm in view. In other words, while details are left to the investigator, the managements of basic research sections of industrial laboratories operated in this way still retain a final control over the kind of research that is done.

Some variant of these managerial patterns is to be found in each large industrial research laboratory with which the writer is familiar. Final decisions on research projects are made by the management of the laboratory, while the staff is called upon to make proposals on projects.

It is true that the output of industrial research laboratories includes work that is reported in reputable scientific journals, and this suggests that many of their contributions are significant and important. In

[58] National Science Foundation, Science and Engineering in American Industry, at 3 (1956).

> millions of dollars in the development of new commercial products and processes, since competitors will be free to copy them.
>
> These same companies are also leading contributors to the national defense effort. Disruptive influences in their business will be reflected in that effort. More important will be the further retardation of invention in two such vital fields as electronics and computers, both of which are of critical importance to atomic energy, aircraft, and guided missiles.

An inference contrary to the view expressed by Mr. Spencer may be drawn from the data and analyses in part I of this inquiry. There, it is suggested that so long as pressures for competitive product design and cost reduction continue to press these firms, they will continue to maintain large industrial research establishments and will expand them in accordance with the requirements of this competition. The availability of the patenting privilege, it appears, has not been the controlling factor in their industrial research activity. Rather, on the basis of the analysis contained in this study, it appears likely that curtailment of patent privileges (1) will not result in a decline in the industrial research budgets or research employment in these firms; and (2) that the scope of their industrial research activity will continue to grow.

This writer has been advised by competent persons in the firms concerned that their industrial research budgets and the scope of their research activity are to be expanded during the coming years.

Why is Mr. Spencer's prediction at variance with the planned performance of these firms? The source of the variance, it would appear, lies in his assumption that the availability of the patent privilege has been the controlling factor in determining levels of industrial research activity. To the extent that this assumption is wrong, the predictions based upon it tend to be contrary to the facts.

In this writer's estimate, the more adequate explanation for IBM and A. T. & T. research trends may be found in the analysis presented in chapter VI, above. In other words, the growth of product competition and competition for production cost reduction, account for the general expansion of industrial research activity. The same proposition explains why A. T. & T. and IBM are under pressure to maintain and expand their industrial research activities. If they did otherwise, they would lose position in the competitive race among firms. Granted that these firms have made effective use of their patent rights as one of the available weapons in interfirm competition, it does not follow that abridgment of those rights through the decree alters the competitive factors that exist. Neither will abridgment of patent rights lead them to abandon the other competitive weapons which they have been permitted to retain—in this case, their industrial research facilities.[64] On the contrary, they have every inducement to strengthen and expand these facilities to make up for what they have lost.

[64] This analysis would not necessarily apply to industrial research in which the primary interest has been, not the competitive advantage derived therefrom, but the royalty income obtainable from licensing others. Under such conditions the abridgment of patent rights could lead managements to reduce research outlays. However, research aimed primarily at licensing income has not been the dominant characteristic of industrial research management.

C. PUBLICATION POLICY

The act of publication is a crucial aspect of the production of knowledge, for publication of research findings in sufficient detail permits other investigators to check on the validity of reported findings, and opens the way for the extension of the frontiers of knowledge. The patent system is alleged to further and facilitate such publication in two ways.

First, in the view of industrial research managements, patents are a form of scientific literature. The fact is, however, that patenting often does not really constitute publication in the sense described above—at least, not adequate publication. The writer is advised that, in many instances, one of the arts of the patenting process is that of writing patent applications in such a manner as to secure the most coverage with the least disclosure. As a result, as shown in chapter VII, above, the knowledge disclosed, even in the most elaborate patent coverage, often is not sufficient to enable another independently to duplicate the processes involved.

Second, holding a patent is commonly regarded as a safeguard that permits public disclosure of the subject invention through the presentation of formal papers thereon before technical and scientific societies—disclosure that they otherwise would not dare risk for fear of its appropriation. Directors of the larger research laboratories emphasize this consideration, for, in their view, publication of technical papers by their staff is important in attracting top technical talent without which their research facilities would deteriorate.[59]

In fact, however, this procedure works only imperfectly, at best. The larger industrial laboratories tend to maintain systems of "closed" (confidential) literature comprising reports and technical papers available for circulation to selected employees of the company only. A result is the substantial isolation of many industrial research projects which, in turn, has led to extensive duplication of lines of work among the laboratories of different firms.

These considerations of secrecy in industrial research laboratories become increasingly onerous as industrial laboratories employ more and more scientists to supply the raw material for new technologies. As more and more of the information developed in industrial laboratories comes under the ban, their staffs become increasingly dependent for knowledge upon the free communication that exists among nonindustrial scientists, while their own publication policies restrict such communication.

Publication policies vary among firms. The fact is, however, that in the typical business-managed laboratory, the interest in spreading and furthering knowledge is necessarily a subsidiary consideration to the business interests of the firm in its utilization of knowledge. In other words, if the business interests are promoted by secrecy, then the information is kept secret, however much good in other respects might flow from its publication.

As one research director puts it: The research department is a trustee, a custodian of scientific information for the company; therefore, the managers of the department must take a banker's attitude (as if it were dealing with money) and adopt a conservative view with respect to publication. In this laboratory, a major one in its field, it

[59] See note 52, supra.

E. LIMITS ON THE POSSIBLE EFFECTS OF HAVING NO PATENT SYSTEM

In evaluating the effect of doing away with the patent system, one must consider the fact that the major part of technical knowledge already lies outside the patent system. Thus, much technical knowledge is unpatentable because it is part of the public domain of knowledge. Some is unpatentable because it does not meet the "invention" and other tests of the patent law. Some is unpatented because the owners or inventors choose not to patent it. Moreover, the body of underlying science generally lies outside the "subject matter" limits of the patent law and this type of knowledge is becoming increasingly important for industrial applications, as refinements in processes and products increasingly require new knowledge of physical principles. Such knowledge is not only outside the scope of the patent system on the whole, but its production is centered mainly in the universities where the production of new knowledge is an end in itself.

The tradition of free publication in science reveals an important characteristic of knowledge. Unlike physical things, knowledge can be shared (given away) while still retained. This characteristic of technical knowledge would be unaffected by the absence of the opportunity for making patent claims.

This consideration will become more important for the larger industrial research laboratories as they extend their activity to more theoretical problems in science which they will require for various types of applied work. Such knowledge, developed in industrial research laboratories, must also be subjected to the test of free, independent scrutiny, in order to control the validity of the results. From this standpoint, not even the largest industrial laboratories can be independent of the larger community of scientists and technicians. It has been suggested, in chapter III, that certain of the larger laboratories attempt to get this effect by employing consultants. However, this device can only approximate the check on validity of results that comes from free publication, with opportunity for independent review of research results.

Under present conditions, it is not uncommon for industrial laboratories to withhold new knowledge from publication for as much as 4 to 5 years or more. (See ch. IX, sec. c.) In the absence of a patent system, it seems clear that these practices would continue and the only question is whether, and to what extent, knowledge would be withheld still more. But there are practical limits upon how long information can be kept secret, limits that vary with the nature of the information and how it is used. And the gap between the extent of secrecy with a patent system and without it is narrowed by the forces and self-interest that induce a business concern to hold knowledge to itself as long as possible, patent system or no patent system, and even when it does let it go to reveal as little as possible. It is still further narrowed by the dictates of self-interest that induce disclosure even when it seems possible to keep information secret. Obviously, the business pressure on firms to delay as long as possible the utilization by others of particular knowledge, would remain operative. At the same time, the forces that impel a concern to disclose and share with others the knowledge it acquires, would continue. As for nonprofit laboratories, the elimination of patenting would actually remove a is "bread and butter" to universities, this is not true in an industrial laboratory. In a business-managed industrial research laboratory, business requirements are the major consideration in deciding what to publish.

These data indicate that important restrictions on publication stem from the use of knowledge as private property. Patenting has been one instrumental device in such efforts.

D. PROPORTION OF SCIENTISTS EMPLOYED IN INDUSTRIAL LABORATORIES

The analyses given above indicate the direction of the effect of typical industrial-research policies as they bear on important aspects of the promotion of science. It is necessary, however, to have some quantitative indication of the scope of these effects, insofar as that might be shown by the number of scientists and engineers employed in industrial laboratories. The data given in chapter VII certainly show a marked growth, especially during the last 15 years. The recent survey by the National Science Foundation disclosed that, in the view of industrial-research managers, basic research comprised only about 4 percent of total industrial-research activity. As an average statement for all of industrial-research activity, this is a small figure. There is, however, substantial variation from industry to industry in this respect.[61]

Summary

In summary: Patent-oriented control of research, as one aspect of of the use of knowledge as property, leads to effects that run contrary to the requirements of efficient promotion of science. Business criteria, like any other closely defined criteria for selection of research problems, restrict the scope of acceptable problems and the freedom of the investigator. Business requirements for keeping knowledge secret block the free publication that is a necessary part of the process of inquiry.

The effects noted here are especially important in the promotion of science because of the interdependence and need for integration of knowledge which was described in chapter III, above. Under such conditions, the people who decide on research projects, the criteria used, and policies on publication affect the degree to which scientists and engineers may participate in the necessarily integrated effort of the expansion of technical knowledge. Insofar as the pursuit of patent rights contributes to research and publication policies that contradict the requirements of interdependence and integration, it may be said that the direction of effect of a patent system contradicts the requirements for the progress of science and technology.

CHAPTER X. WHAT WOULD HAPPEN IF THERE WERE NO PATENTS?

What would be the impact on the production of technical knowledge if there were no patent system; that is, if technical knowledge were not subject to property rights at all?

[61] National Science Foundation, Science and Engineering in American Industry, at 18 (1956).
There have been recent indications that the number of scientists with advanced research degrees employed in industrial research is going to increase. See the ads for employment of scientists and engineers in any current Sunday issue of the New York Times. This is also suggested by the expansion plans made known to this writer by the directors of several laboratories. Also, see Fortune, at 96 (January 1956).

PART III. THE INTERRELATION BETWEEN THE PRODUCTION OF TECHNOLOGY AND ITS USE AS PROPERTY

CHAPTER XI.—CONCLUSIONS BASED UPON THE RELATIONSHIP BETWEEN PART I AND PART II

At the very outset of this inquiry the leading question was defined: Does the patent system promote science and the useful arts? In an attempt to answer this, an examination was made of the conditions of decision making under which technical knowledge is produced. In the second part, an analysis was made of the effects upon the production of science and its application which flow from the use of property rights to technical knowledge.

This study is devoted, and limited, to these selected aspects of the patent system and is based upon a study of a small number of major industrial and nonprofit laboratories. Its many other aspects, with the extensive implications they may hold for many occupations, this study does not attempt to evaluate. It is concerned only with the effects upon the promotion of science and the useful arts that stem from the existing patent system.

This chapter summarizes the leading findings of this inquiry and examines their implications with respect to the principal question under study. The chapter is in three sections. The first expresses and examines the view that the patent system has become obsolete as a principal device for the promotion of science and technology. The second examines the role played by the patent system under modern conditions as an incentive for the production of science and its technical application—the role in which the patent system is generally viewed as playing a significant part. The third section suggests ways in which science and the useful arts can be promoted and further stimulated under contemporary conditions without the assistance of a patent system.

A. IS THE PATENT SYSTEM OBSOLETE?

The patent system has lost the effectiveness that it may once have had as a way of promoting science and the useful arts. This has been owing to changes in the ways of producing knowledge, and to the damaging effects that competitive patenting activity has had upon the conduct of inquiry and research.

1. From solo inventor to cooperating investigator

The system as it is now constituted requires the designation of an "inventor" as the person responsible for the production of given technical knowledge and its expression in the form of a new object or process. In actual operation, designation of a specified individual as "the" inventor often becomes increasingly difficult, if not impossible, under modern conditions because of the division of labor and interdependence which exists. Research is increasingly a joint process to which persons with various technical skills contribute necessary parts.

tive creative activity of individuals and particular groups. Secrecy usually results in unhealthy competition among individuals or groups.[62]

These same considerations apply to secrecy practices among nonindustrial laboratories.

B. EFFECT ON THE SCOPE OF INDUSTRIAL RESEARCH

In chapter VI, an attempt was made to define the principal determinants for the conduct of technical research by industrial firms. The pressures of competitive advantage in terms of new products and cost reduction were specified as the crucial determinants. To the extent that requirements of this kind of competition among firms are, indeed, the underlying pressures for expansion in industrial research, it obviously follows that the absence of a patent system could not have a controlling effect on the magnitude of industrial-research outlays.

There is, of course, no way of measuring with any degree of accuracy what effect, quantitatively, the elimination of patents would have upon research and research results. In order to get some clues that might shed light on this point, however, various industrial research directors were asked during the course of this inquiry: What would you do if the patent system were no longer available tomorrow?

(1) In one case this writer was advised that these effects would follow: (a) No infringement problems would exist in the absence of claims to exclusive property rights to knowledge (i. e., patent rights); this would influence the character of design since many aspects of the products of this industry and the processes it uses are affected by patent claims. (b) The outlays for engineering work in this firm would not be affected because, in the opinion of this informant, the firm was doing all it could in this field already. On the other hand, owing to competitive reasons, it could not afford to reduce its engineering research. (c) The character of engineering work would, however, be affected because a substantial part of its present work is directed to circumventing patents held by other firms. In the opinion of this informant, his firm has not been benefited by a patent position. On the contrary, it has been hampered by the existence of patent claims.

(2) In another firm the opinion was that, in the absence of a patent system, (a) only such things would be worked on as could be kept secret, and (b) the firm would abandon research that it could not benefit from. Those consulted were not optimistic about keeping research and inventions secret. The writer was informed by the managers of this laboratory that they had strong grounds for supposing that their system of information security, elaborate as it was, had not altogether served its purpose. They cited an instance in which the character of one of their products was purposely altered in an arbitrary way that would not affect its operating characteristics. Within a few weeks the products of a competing firm showed the same alteration. This, in the opinion of this writer's informants, was not mere coincidence, but was probably traceable to leaks in their system of information security. Indeed, in the casual estimate of one informant, it is not possible to keep a secret inside the company for more than 3 months.

[62] Engineers Placement Guide, at 11 (November 1955).

What of the connection between patenting and research? The writer has attempted to explain the growth of research activity as the effect of competition among firms for advantages in product design and production cost. These factors would explain the absence of a clear correlation between patenting and industrial research. Indeed, these factors, and not the attractions of patent privileges, explain the recent decisions of A. T. & T. and IBM to expand their research activities, even after their patent privileges were circumscribed. This evidence does not support the contention that patenting and industrial research are closely linked.

Altogether then, the evidence reviewed here runs against the proposition that there is an important causal connection between patenting and research.

Wherever patenting is an important adjunct to technical research, practices are introduced which tend to retard the aggregate progress of science. Patenting interest leads to emphasis on problems of limited scope, while areas offering little promise for patentable results tend to be bypassed. Managerial forms of decision making restrict the initiative of research scientists. Finally, the pressure for secrecy that surrounds patenting leads to restrictions on the flow of technical knowledge, both within and among laboratories.

These effects are taken for granted in industrial-research laboratories. However, their extension to the universities will, if the present trend continues, inevitably weaken the latter as mainsprings of scientific research and training.

B. THE ROLE OF THE PATENT SYSTEM UNDER MODERN CONDITIONS

1. The patent system is being bypassed

Such expansion in patenting activity as has occurred since 1900 is trivial compared to the sixteenfold increase in the number of scientists and technicians in the United States.[66] Several developments have contributed to this effect. These include major programs in government to promote science under nonprofit auspices; failure of even the industrial firms to use patenting; the utilization of patenting for purposes other than the promotion of science and the useful arts; and, finally, the hindrance to the use of the patent system that results from the awkwardness of its operation.

2. Promotion of science by private and Government organizations

During the last decade, and especially since World War II, the promotion of science as an end in itself has become an increasing concern of both private and Government activity. Until World War II, the major private foundations like the Rockefeller and Carnegie Foundations were of major importance in the sponsorship of scientific work, especially in the universities. After World War II, the Federal Government entered this field. By 1955 the Federal Government had become the most important source of funds for scientific and technical work of all types.[67]

At present the National Science Foundation is established as an important arm of the Federal Government for centralizing the promotion of scientific activity. Research projects proposed by scientists

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[66] See the tables in ch. VII on employment of scientists and engineers, and patenting activity in the United States since 1900.

[67] National Science Foundation, Federal Funds for Science, pt. III. The Federal Research and Development Budget, Fiscal Years 1953, 1954, and 1955 (1954).

Even where it is possible, some firms, especially the largest, expressed doubts whether they could afford to impose absolute security policies upon the knowledge produced in their laboratories. Thus, one major firm indicated that considerable licensing is now done to smaller firms in the industry, the reason being that it prefers to have these smaller units continue as competitors in order to lessen its own exposure to antitrust prosecution. In order to assure this, however, the management of the major firm regards it as essential that the smaller concerns share the information on products and production methods that the larger firm has developed or acquired. Without this information, the smaller firms would suffer a major competitive disadvantage and would soon be forced out of the field. To the extent that such considerations influence a firm's policies, it is important to note that the practices would probably be followed irrespective of whether or not a patent system existed.

In testimony given in 1940, Charles Kettering, then vice president in charge of research for General Motors, discussed the relation of patenting to the operation of General Motors' laboratories. He agreed that the sheer force of competition in the industry would probably require the operation of their industrial laboratories, even in the absence of any patent system at all.[63]

1. A test case

Is there any indicator, close at hand, of the effects on industrial research from the removal of patent rights? One way of gaging this is to look at the experience of major firms whose patent rights have been recently abridged as a result of federal antitrust action. On January 24–25, 1956, for example, the Federal Government announced consent decrees in antitrust cases against the American Telephone & Telegraph Co. and the International Business Machines Corp. Under the terms of these decrees, these firms were required to make available to other firms many thousands of patents as well as related technical knowledge, either at reasonable rate of royalty, or on a free basis altogether. These decrees provoked a discussion among persons interested in the patent system. One point of view was stated by Mr. Richard Spencer, a member of the New York bar and one time First Assistant Commissioner of Patents. Mr. Spencer, writing in the Wall Street Journal (April 10, 1956), declared as follows:

> * * * A. T. & T. and IBM are the great pioneers in research and invention in their industries, which accounts for their leadership and their strong patent positions, as well as for the fact that they were selected as defendants. Under the decrees, not only have their long-established methods of doing business been disrupted, which will interfere with efficient operations for years to come, but management will no longer be in a position to authorize the expenditure of

[63] The following is the text of the relevant testimony:

Mr. O'CONNELL. * * * It occurred to me that even in the absence of any patent laws at all, the mere force of competition in the industry would probably require the type of organization you have been describing.

Mr. KETTERING. I imagine so, yes; but I am a terribly optimistic person on what can be done if we get coordinated right * * *.

Mr. O'CONNELL. I don't want to press the point, Doctor, but apparently organizations such as yours would undoubtedly continue to function and would be forced by competition to function even were there no patent laws.

Mr. KETTERING. We don't run our organization for the purpose of taking out patents. We think only of the general problems. * * *

TNEC hearings, supra, note 14, at 16311.

data available to this writer indicate that the introduction of patenting into scientific institutions has damaged their productiveness.

2. Industrial research with and without patents

Industrial firms, on the other hand, will continue to operate and expand their research facilities in order to serve their particular competitive requirements, whether a patent system exists or not. These units, and others, will continue to rely primarily on the nonprofit research institutions for expansion of the underlying body of science from which technological application is nourished. As for their own research, it is true that industrial firms have been able to utilize the patent system as a device to protect their property rights in the knowledge they develop. Nevertheless, in the writer's judgment, it seems likely that industrial firms would continue to operate and expand their own industrial research facilities even if the patent right were no longer available.[69]

3. Recognition to scientists and technologists

Ways are wanting for giving public recognition to scientists and engineers, whose work contributes significantly to the general welfare. It would be appropriate and useful, in the writer's opinion, to establish a system of public honors and awards to recognize and reward notable achievements in the production and application of technical knowledge. An annual program of honors and awards could be administered by an existing body like the National Academy of Science. By this means it would also be possible to give recognition to those people who continue to function as independent inventors, outside of the employed occupations.

The patent system does not serve these functions. An abundance of testimony before the Senate Subcommittee on Patents, Trademarks, and Copyrights indicates that individual scientists, engineers, and the group of independent inventors, have been the very people least served by the patent system as it now operates.

Summary

In summary: The evidence and analyses of this study indicate that there is a growing disharmony between the efficient production of new technical knowledge and the effort, through the patent system, to treat that knowledge under property relations. This disharmony is intensified as the division of labor in science increases and, as a consequence, the conduct of inquiry becomes increasingly social production that requires the integration of interdependent technical skills. These developments make it increasingly difficult to specify what is new, what is invention, and who is an inventor. The effects from these factors would not be essentially altered, in this writer's opinion, by variation in the rules for establishing property rights to knowledge.

The effort to operate a patent system formulated for the technological conditions of a century ago has proved to be increasingly awkward. The problems of patent-system operation, however, do not stem primarily from administrative shortcomings or from the absence of ingenuity among the able attorneys, judges, and Patent Office staffs who administer the system. Rather, they stem from the inability to apply the conceptions of a bygone era to the contemporary conditions

[69] The writer regards the cases of IBM and A. T. & T. (ch. X) as a crucial test of this question.

C. EFFECT ON AREAS OF INDUSTRIAL RESEARCH

At present, among the larger firms in various industries there exist effective divisions of labor with respect to lines of product development. This type of concentration of research effort stems from the high degree of specialization that is required for research in many fields that have been highly developed. It is also a result of the elaborate techniques in design and operation that are required today in many production facilities. At the same time, a certain amount of overlapping commonly occurs among firms. This forms the basis for trading in technical knowledge. The advantages of such practices would continue even in the absence of property rights to technical knowledge. On the other hand, to the extent that a firm now prefers to retain process information on a secret and confidential basis instead of exchanging it with others, the absence of a patent system would not necessarily alter the considerations that cause such trading in knowledge, except as it might strengthen or extend it as a result of eliminating an alternative procedure.

D. EFFECT ON INTERFIRM COMPETITION IN INDUSTRIAL RESEARCH

If the patent system were thrown out, what would be the effect upon (1) research effort and (2) secrecy?

In the estimate of this writer, the absence of an opportunity to patent would probably cause industrial managements to enlarge, rather than curtail, their research efforts. Given the availability of a patent system, the possession of industrial laboratories as a way of securing knowledge is supplemented by the ability of a firm to use it as a weapon against competitors by subjecting them to large legal costs in litigation over patent rights. Without patenting, the possession of an operating industrial research facility, able to produce new knowledge adequately and expeditiously, would take on greater competitive importance than it now has. The technical strength of a firm would then rest more directly upon its own ability to produce new knowledge, since it could no longer resort to this strength to exclude, harass or levy a toll upon competitors.

As for secrecy, the present types of secrecy now surrounding industrial research activity would be maintained. These restrictions give a firm an advantage in the utilization of new technical knowledge for product purposes, or for redesign of production methods. The question is: Would still more secrecy occur? It is difficult to exclude that possibility. There are factors however, that might well result in their being less secrecy than one might expect. The same considerations that now limit the secret use of technical knowledge would still be operative if there were no patent system. The great specialization of work that exists in scientific research requires substantial interchange of knowledge as a necessary condition of fruitful work. Single laboratories, however extensive, must stagnate if they are isolated from the larger scientific community. This view is shared by the directors of leading industrial research facilities. Furthermore, the antitrust considerations that impel large firms to give smaller competitors knowledge needed for low-cost production would continue to have force in the absence of the patent privilege.

source of pressure for secrecy of results and for restriction on the scope of research. In university and similar laboratories, in the absence of a patent system, there would be no alternative but to do research and publish the results freely.[65]

Summary

In summary: There is nothing to indicate that the absence of the patent system would diminish the scope or character of scientific research in the universities. Indeed, insofar as patent pressures were removed from university scientists, this would probably strengthen the universities as producers of science and technology. Moreover, business expenditures for research, in the estimate of this writer, would not be appreciably diminished by the elimination of opportunities for claiming patent rights. It is true that in the absence of patenting, some of the characteristics of industrial research might be revised. Competitive pressures along product and production cost lines, that now impel the expansion of industrial research outlays would, however, continue to be operative.

[65] If universities attempted to do research and make the results secretly and exclusively available to certain firms, they would be transforming themselves into adjuncts to industrial research managements. These activities might come within the scope of the income tax regulations that were cited in chapter VIII, above. The effect could be to alter the basic character as well as the tax-exemption rights of a university.

Moreover, research scientists and engineers are now, in the main, employees. Their incomes are substantially unrelated to their patenting activity.

These conditions in research work make it difficult to specify the elements of originality in new technical knowledge which the patent law requires. For example, as the scientific and technical occupations develop, more persons are able to do given types of inquiry. One test for originality is that work should require more than ordinary skill. However, as technical knowledge of a high order becomes widely diffused, even the most elaborate skills become ordinary in the sense that many persons are competent to carry out given types of inquiry. The evidence of this development is found repeatedly in the form of parallel development of research and development with respect to problems of great complexity.

The very question: "Who is the inventor?" comes from another period in industrial history when the work of producing new technical knowledge was characteristically carried out by single persons. The continued use of the category "inventor" under present day conditions is plainly anomalous. The word continues the same, but its meaning has changed. The lone inventor of 1800 has given way to the cooperating investigator of the 20th century.

The insistence of the patent system that the patent application specify an "inventor," has often led to exaggerated claims for the scope of work done and for priority. In connection with a recent and important technological development, a firm claimed publicly that its technicans had "conceived, invented, and developed" a certain product. This claim is not supported by an examination of the history of research in this field, available through the published literature. The published history disclosed a discrepancy between the strong claim for exclusive development made by the firm and the actual contributions of investigators employed in various laboratories, of which this firm was only one. In other words, the claim for exclusive invention may reflect, not so much the actual contributions that were made, but rather the efforts to develop a network of commercially important patents as a useful weapon in the commercial combat that occurs among business managements.

2. Patenting as an incentive to the production of science and its application: Patenting pressure results in damage to the process of inquiry.

Owing to the fact that patents have long been granted for inventions, it is an apparently plausible inference that the patent system has had some facilitating effect on inventing. That, however, is not in question here. The problem of this study is rather: Has the patent system had an important, dominant effect in promoting the progress of science and the useful arts?

In order to prove that the patent system is the cause, and invention the effect, one must demonstrate two things: first, that there is a significant correlation between activity in patenting and research; second, that there is a defined intervening chain of events which links patenting with research. On the basis of the data reviewed in this study, it appears that neither of these requirements of proof can be satisfied. The evidence at hand, for particular firms and for industry as a whole, shows that research activity has expanded without parallel development of patenting. Accordingly, there is no evidence here of correlation between patenting and inventing.

under which technical knowledge is produced. At the same time there can be little doubt that the patent system has been a useful instrument in industrial management's competitive process.

In this investigation, attention has been focused on the problem: Does the patent system now fulfill the constitutional purpose of promoting science and the useful arts, as indicated by the operation of industrial and nonprofit research laboratories? On balance, based upon the study of selected typical industrial and nonprofit research laboratories, the answer is "No."

The patent system in the contemporary scene has not, as a rule, promoted conditions that facilitate research in science or the industrial arts. On the contrary: In universities the effect of patenting pressures has been to interpose managerial controls and commercial pressures where free, uninhibited inquiry is needed to promote the flow of science. In industrial laboratories research in the useful arts has been expanded rapidly, without a parallel growth in patenting activity. Moreover, the experience of a few firms, whose patent privileges have been recently abridged, indicates that these managements maintain and expand their industrial research in order to cope with problems of product and cost competition. The development of research in these and similar firms will bear close watching.

With or without a patent system, the efficient pursuit of knowledge in the universities and other nonprofit institutions will continue, within the limits of available resources, so long as the production of knowledge is treated as a sufficient end in itself. Industrial firms will continue to enlarge their research in the useful arts as dictated by competitive needs, with or without patent privileges. Henceforth, in the judgment of this writer, the main impetus for the promotion of science and the useful arts will come, not from the patent system, but from forces and factors that lie outside that system.

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in various fields must pass the scrutiny of committees of their colleagues set up to allocate available funds.

Patents are taken as an incident to work performed by some Federal agencies, although they are of lesser importance in the work sponsored by the Public Health Service and by the National Science Foundation, as they are for the scientific activity sponsored by private foundations. Generally, the product produced by the investigator becomes part of the public domain of technical knowledge.

3. Patents as instruments of interfirm competition

Although patenting has not kept pace with the expansion of scientific and engineering research, and has failed to achieve its constitutional objective of promoting the progress of science and useful arts, its continued use has been sustained because of its importance as an instrument of business competition. In this realm there belong the cross-licensing and trading in patents and other comparable business transactions which form parts of complicated networks of interfirm agreements both within and among countries.

4. Complexities of the patenting process

Both the administration of the Patent Office and adjudication of patent cases in the courts have become so complicated as to present formidable and costly obstacles to the use of the patent system, especially by individual persons. This is the inescapable inference from testimony given before the Subcommittee on Patents of the United States Senate.[68]

There may well be some purely administrative causes for these developments. Still, there is no avoiding the fact that the problems of identifying an "inventor" and an "invention" under modern conditions impose formidable difficulties for both the Patent Office and the courts. From this standpoint, major difficulties of operating the patent system must result from the formal attempt to treat today's producers of technical knowledge as though they were "inventors" of 1800.

C. REQUIREMENTS FOR THE PROMOTION OF SCIENCE AND THE USEFUL ARTS UNDER PRESENT CONDITIONS

The supply of technical knowledge and the means for its production are major resources for the whole society. How is the constitutional mandate "to promote science and the useful arts" to be implemented under present conditions of the production of knowledge in nonprofit institutions and in industry?

1. Support for the production of knowledge as an end in itself

The weight of evidence is strongly in favor of the following as the most efficient means toward this end: ample financial resources for the universities and other nonprofit institutions which operate to produce knowledge as an end in itself; maximum freedom for initiative by the investigator as a guiding principle of the allocation of funds and decision-making in institutions; encouragement of free publication and other scientific communication as a point of principle.

There is no place in such a scheme of things for the operation of any system that reserves to specified individuals the exclusive property rights, patented or otherwise, in knowledge thus developed. The

[68] See hearings on the American patent system, before the Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee on the Judiciary, 84th Cong., 1st sess. (October 10-12, 1955).