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INVENTION AND THE PATENT SYSTEM

MATERIALS RELATING TO CONTINUING STUDIES OF

TECHNOLOGY, ECONOMIC GROWTH, AND THE VARIABILITY OF PRIVATE INVESTMENT

PRESENTED FOR CONSIDERATION OF THE

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CONGRESS OF THE UNITED STATES

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LETTER OF TRANSMITTAL

DECEMBER 21, 1964.

To Members of the Joint Economic Committee:

Submitted herewith for the consideration of the members of the Joint Economic Committee and others is a study "Invention and the Patent System" by S. C. Gilfillan, Ph. D.

The findings are entirely those of the author, and the committee and the committee staff indicate neither approval nor disapproval by this publication.

PAUL H. DOUGLAS,
Chairman, Joint Economic Committee.

DECEMBER 18, 1964.

Hon. PAUL H. DOUGLAS,
Chairman, Joint Economic Committee,
U.S. Senate, Washington, D.C.

DEAR SENATOR DOUGLAS: Transmitted herewith are materials on "Invention and the Patent System," the product of many years of research and preparation by its author, S. C. Gilfillan, Ph. D.

This study is related to the Joint Economic Committee's continued interest in problems of technology, economic growth, and the variability of private investment and was presented for consideration by the committee and the staff.

JAMES W. KNOWLES,
Executive Director.

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INVENTION AND THE PATENT SYSTEM

A first appraisal of the patent system. Made as any appraisal must be, by comparing the subject with its next best and possibly better alternatives. With further suggestions for the understanding and help of invention.

BY

S. C. GILFILLAN, PH. D.

CHAPTER 1

A PREFACE AND CONSPECTUS

[1] Whole libraries have been written about the patent law and system, yet nowhere does one find a serious attempt to *appraise* the patent system. Many have lauded it, a very few have damned it, many have described it, proposed betterments in it, told its history, etc., but none have appraised it. To appraise a thing is to set forth judiciously how good or bad it is; and to do this *requires comparing it with its next best and possibly better, partial alternatives*, both actual and feasible. The patent system has been again and again compared with the simple abolition of patents. But that is not the next best alternative—it would be a stupid substitute, or as we commonly say, "no substitute." If we are appraising a restaurant, we must compare with other restaurants, available or feasible, not with going hungry. And so with the patent system, to appraise it we must compare it with our other current institutions for supporting invention, and perhaps with some that might be installed.

[2] But has the patent system any alternatives? It is often thought of as our only institution for the encouragement of invention. Yet we have 15 or so rival institutions serving this end, in such abundant and approved use that, as we shall later show statistically, they have already come to motivate a much larger share of American inventing than patents do. These substitutes are: Governmental inventing, in Federal laboratories and through contracts, mostly in military lines (but civil and military uses for inventions constantly interchange); Government assistance to inventors with their own projects; manifold governmental services through libraries, education, etc.; tax benefits for earnings spent on invention; philanthropic foundations for invention; universities, whose chief contribution is in more basic research and science; trade association inventing, frequent in America, subsidized in Britain; sale of know-how; the vast field of commercial unpatented, mostly unpatentable invention, improvement, and research; employee suggestion systems, hardly ever using patents; compulsory licensing of patents by court order and setting of royalty; awards for inventions made and prizes for inventions to be made; monopolies and corporate bigness—whether good or bad these made patents less necessary to secure abundant use for one's improvements, although industrial monopoly also adds a motive for patenting; secrecy, occasionally supported by the common law; and patent pooling, which like compulsory licensing and the others named, is essentially a rather different thing from the patent system. We define the patent system as everything that goes with the more or less exclusive, competitive ownership of inventions through patents (¶ 126).

[3] These are our present and principal means for eliciting invention, already in the aggregate much more important than the one fa-

miliar one, the patent system. But there are the possibilities of devising still other, new and better means, of which one will be examined and proposed: the development of patent pooling by making semipublic, nonmonopolistic *trade associations* the chief sources of invention and holders of (nominal) patents, mostly but in no case fully to replace the other 14 existing institutions for the support and direction of commercial invention. All 17 systems will be briefly or more fully described, with some of their subvarieties, measurement be attempted of their present extent, comparison made of their principles and their efficiencies, and some attempt made to show what fields each is best for, which ones are advancing and which retreating, and which offer the best hopes for the future, and most merit fostering. In a word, we shall make a novel attempt to *appraise* the patent system and its alternatives, even if we cannot go far in proving our valuations. Since all of us concerned with invention or patents *must* act, must daily throw our weight toward one system or another, it seems worthwhile to seek even a first, partial, inconclusive appraisal of the rival supports for invention, rather than to continue choosing without comparison or appraisal.

[4] It is because we see that the patent system has alternatives, actual, growing, and already outranking it, that we do not follow the dogged, not very hopeful conclusion of William H. Davis, chairman of the Patent Survey Committee 2 decades ago. Patents are inevitable for the present, he said, and (ignoring our actual rival institutions) "The present administration of our system is so encumbered with delays and frustrations that its every virtuous aspect and every vicious aspect are entangled in and distorted by these inefficiencies—so much that I think we waste time in theoretical discussion of its virtues and vices under present conditions. The most that we can do, I believe, is to try to define standards for an effective patent system, and then devote our energies to bringing our system up to those standards." [1] Even if we should not envisage the patent substitutes that we can and are turning to, this is rather pessimistic advice, since the same doctrine has been advocated for a century past, during which the patent system has acquired no marked improvements, unless by court antitrust action, and seems to be falling further behind in utilization, promptness, validity and legal favor, in spite of all efforts at reform by the Patent Office, Congress, commissions, and the courts. Davis' recommendation that we thoroughly reform the patent system before we inquire what sort of a system we want for securing invention, advocates a course that has been failing right along. Should we not rather examine whither we are actually faring, and how we might steer best, among the various actualities and possibilities? Such is the purpose of this book.

[5] While thus comparing the means for securing invention, we should also make some distinctions of the kinds of invention. We shall especially single out for attention a most important, valuable kind of invention which yet is much neglected today, because neither patents nor any of our present 16 rival means gives it any serious early support, in most cases that fall outside the military. This forgotten treasure is *fundamental civil invention*—the basic new starts like television, the home radio-printed newspaper, the helicopter, jet propulsion, flexible glass, a prefabricated house, voice-operated type-

writer, and print-reading machine. These fundamental inventions take so long to come to fruition, because we provide no effective support for their development, that our 17-year patents expire long before they can reward the earlier inventors through royalties from abundant use. Some helps will be suggested for these especially, as well as for other kinds of inventions.

[6] Finally, the encouragement of invention seems to demand urgently improvement of the quality and number of inventors, men who are both trained in engineering, chemistry, or technology, and also, quite another matter, men who have a liking and a developed, trained gift for invention, originality, creativeness. Our technic rivalry with the Communist world, and the demands of fundamental invention, especially point up this need. And examination of the training of our engineers, the scheduling of their lives, which still often defers inventing till middle age, if ever, and comparison of the successes of different types of inventors, indicates things gravely wrong and remediable, for the cultivation of this type of man so essential to our survival as a nation and an advancing culture.

[7] Military as well as civil inventions will be considered, although with inventions exclusively military patents are seldom used and never important. Our reasons are that the military category has risen to be about half the total (cf. chart 3), and because it is impossible to separate military from civil invention in any study of how the invention business is organized and might be improved, what forces play upon it, and what social results it has, including the evoking of further inventions. Military and civil inventing are constantly pursued in the same commercial or university laboratories by the same staff, as they turn from one project to another, and whether separated or not the inventors are trained in the same schools, illumined by the same sciences, enwrapped in the same civilization; and the inventions they turn out are constantly shifting between civil and military uses. Consider aviation, for instance, or atomic physics and energy, or medicines, insecticides, and food preservation (by radiation, e.g.) needed and invented by the army, but equally applicable for civilians, or navigation devices, sonar now turned against fish, tank engines, bulldozers, metallurgy, chemistry, the aerosol bomb the army developed to rid quarters of mosquitoes, now used as a boudoir spray, and an infinitude of civil arts turned to military use and vice versa,[2] (¶ 436). The two fields are largely inseparable in scientific reality, and to be distinguished only in formal and temporary discussion (¶ 104.5).

[8] Always our outlook will be that of the social scientist serving the statesman, not that of the inventor, patent lawyer, industrialist, or historian, who have authored most of the discussions of invention and patents. In those professions the big question anent patents and invention is apt to be either technologic or Who gets the reward? But to the economist or other social scientist and to the statesman, the big quesion is: By what social arrangements can the most additional wealth be created, for our country and to some extent for the world?

[9] Throughout our book we have sought to *quantify* things, as science ever demands, to furnish *statistics* wherever possible, and in many cases where impossible, one would have thought, impossible to find, or to contrive statistics, by sound interence, reasoning from one quantity to another. Naturally, any such statistics will be highly

inaccurate. This will bring a prompt snort from many: "What use are statistics that are highly inaccurate?" The answer may be difficult for persons not deeply trained in social science statistics. Let us begin this way. The most accurate of all sciences is astronomy. Some astronomical data are carried out, in accuracy, to many digits, the length of the year to 10 digits. And yet those same astronomers sometimes offer us statistics whose Probable Error is 1,000%! Say on the distance of an undistinctive star, or on the number of habitable worlds. Why do astronomers, *virtuosi* of accuracy, sometimes offer us such vastly inaccurate statistics, whose very first digit is probably wrong? Why? *Because they understand that some faint idea of magnitude is better than none at all*—and an idea with a probable error of 1,000% is better than one probably 10,000% wrong. None of our statistical guesses will be so wild as some of those astronomers', and we shall endeavor to give some idea of the probable degrees of inaccuracy.

[10] As astronomy is the oldest, most accurate, and one of the most perfect sciences, so the social sciences are the youngest, least certain, and least accurate. One may say that no social statistics are ever true beyond an average 2 digits, i.e., 1 part in 50, or $\pm 1\%$; and usually we must be content if our first digit is probably right. Constantly, social scientists give an air of greater accuracy by copying governmental or commercial statistics half a dozen digits long, although the later digits are not true in any real sense. Perhaps we report "736 people, accurately counted". But our accuracy is illusive, based on false assumptions of identity or equality, even if the *count* was accurate. A baby, a moron, and a great leader add up to three *what*? You said you counted 736 people. Just *what* did you count? Nothing of accurate significance, in any case. In this book we may count patents, or infringement suits, or dollars reported spent on research. All is individual variability and hence totals of we can't well say what; so we can only hope that we have got the first one, or at best the first two digits right. But yet and always *some* idea of a magnitude is better than none, and an inaccurate guess is better than a *very* inaccurate guess, and constitutes an advance in the building of our science.

[11] How should our degree of accuracy-inaccuracy be expressed? There are various ways. The most elegant is a carefully calculated Probable Error, or else Standard Error, $\pm$ so much. A much easier and commoner way is by number of significant digits. Thus we should say that the amount spent on organized Research and Development (R&D) in 1961 was $10.9 billion, not spelling out the sum to the last dollar or penny reported (certainly false). Usually we aim to set down two significant digits; any further ones are doubtless untrue or meaningless, even though they add very *slightly* to the chance of a bull's-eye.

[12] But now a difficulty arises. Say we have 2 of these rounded 2-digit numbers, 4200 and 3.6, that must be added, multiplied, or otherwise combined. Their sum, 4203.6, has 5 significant digits, yet the accuracy of only 2. Our statement's precision is 1,000 times greater than its accuracy. What to do? Round the sum to 4200 again? But that would obscure or deny the addition. Where the reader may wish to check or understand better our proceedings, we were best to leave it as 4203.6, begging him to remember these principles and not accuse us of faking 5 digits of accuracy. But where

that sum or product will be presented as a simple quantity, we should round it. In short, in our and everyone's social statistics, only the first one, or at most 2 digits are to be taken as a statement of truth; the digits following, and especially the last one, are for purposes of *identification* of their sources and of the mathematical procedures.

[13] To check the truth of our statements in so many fields we have sought the criticisms of various experts, and acknowledge with thanks the help of the following who have read parts of the manuscript and given us some criticism. And most of all the editor, Professor John C. Stedman of the University of Wisconsin, who during the 7 years of writing influenced it greatly in all ways. Others, usually also professors, have been Carl F. Christ, Ph. D., Joel B. Dirlam, Ph. D., J. P. Guilford, Ph. D., LL.D., Carl V. Hays, M. E., Ing. Hans von Hortenau, Alfred E. Kahn, Ph. D., Simon Kuznets, Ph. D., Commissioner David L. Ladd, Richard L. Meier, Ph. D., Alex F. Osborn, L.H.D., George R. Price, Ph. D., John A. Rademaker, Ph. D., Joseph Rossman, Ch. E., M.P.L., Ph. D., Barkev S. Sanders, Ph. D., M. Sarell, Jacob Schmookler, Ph. D., Alfred B. Stafford, Ph. D., and Robert Q. Wilson. My wife, Louise Wenzel Gilfillan, has also been most helpful.

The Footnotes, etc.

[14] Our system of Notes, a personal invention, combines in one numerical sequence *discussional* notes at the foot of the page, referred to by superior italic numerals, and *citational* notes indicated in text by superior roman numerals and assembled at the end of the book, all being easily findable by their numerical sequence. By these means the text pages are cleared of notes not of interest to the ordinary reader, and duplication of notes is reduced when the same source is referred to from various points. Thus, one need not hunt backward through pages for an *op. cit.* But a page reference given in a note normally applies only where the note occurred in regular numerical sequence, i.e., the first time the note was cited.

[15] Paragraphs are numbered by full-size boldface numerals in bold brackets at the beginning of each paragraph, and referred to elsewhere by the ¶ sign, like this: ¶ 15:

[16] Abbreviations used include *JPOS*, for *Jol. of the Pat. Office Soc.;* U.S. NSF, for U.S. National Science Foundation; PTCF for Patent, Trademark and Copyright Foundation and *PTCJRE*, for *Pat. Tr-mk & Copyright Jol. of Research and Education*, both at George Washington University. "The present series" refers to the valuable series of studies on the patent system presented by the Senate Judiciary Com'ee's Subcom'ee on Patents, etc., for which this book was originally written.

A Summary of Findings and Argument

[17] The patent system is an institution 488 years old, increasingly substituted by a dozen or more rival institutions for the support of invention, so that it is now an important motivation for probably a fifth of American invention and its necessary researches. It continues in full vigor and usefulness for some kinds of inventions, with likely as large an absolute importance as ever, viz., for commercial inventions

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of some importance, and for minor ones and discoveries so far as these require for their use a patent on some other invention; but patents avail only for the last stage of great new, fundamental starts like the voice-operated writing machine. The inventions most suitable for patenting are made by corporations usually, of less than monopoly size. Attempting to measure in chapter 9 the various sources of support for invention, and for the researches in physics, chemistry, and such sciences that are indispensable and largely inseparable bases for modern invention, we find the Federal Government supports 61% of these, including 15% through tax benefits, highly organized industry 31%, small companies and unorganized inventors 2%, patent pooling 3.7%, Compulsory License, Sales of Know-how, Suggestion Systems, Foundations, and Universities, each about ½%, and the remainder in smaller contributions from State governments, Professional societies, Trade Associations, and Awards. Combining and rearranging categories, we find that private industry *performs* about 70½%, but *supports* only 37%, and fully competitive industry supports about 33%, against Government's 61% and philanthropy's 1.4%.

[18] While roughly maintaining their absolute importance, as we said, patents are shown to have been improving in quality, but losing in favor with the courts, and declining greatly in relative importance because of the prodigious rise of noncommercial invention. The swiftly accelerating rate of American inventing and invention-oriented research is graphed in four charts (¶ 56), which are the first elaborate and fairly satisfactory measures of the rate of inventing and its researches, and which go back for 80 years. With striking agreement and steadiness, these graphs plot rises of 105-fold in output, and around 340-fold in annual inputs or efforts to invent, during the period 1880–1960. In the same years the count of patents to Americans rose only 3.3-fold, little more than the population. The history of patents is sketched, new attempts are made, and others quoted, to measure the value attached to patents, their older philosophy is largely refuted, and their seven sound economic reasons are set forth. These could serve as guides to what patents should be granted, under ideal conditions, and how the whole patent system might be better directed. Four basic merits and seventeen shortcomings and abuses of the patent system are separately analyzed in chapter 7, with statistics for the first time on the full direct costs of the patent system, amounting to something like $3,000 per average patent. Special attention is paid to the sources and remedies for the many invalid ones being granted. Forty-one percent of all sued on to a court conclusion are found invalid, and 21% fail to cover the methods used by the sued "infringer," leaving only 28% definitely victorious.

[19] Chapter 8 is devoted to "Fundamental Inventions—Nobody's Baby." Past history and statistics and a discussion of many great inventions now struggling through a helpless infancy, prolonged often through centuries of difficulty, find their explanation in that neither patents nor any of our other institutions provide any serious support for such basic inventions, save in the military and rare other categories. As we learned a century or more ago that *science* cannot support itself, but must be supported, so we must learn that fundamental inventions, like the reading machine, the voice-operated writing machine, and the desalting of water, are in the same helpless situation as was science.

An important special case is inventions, especially in communication, that are barred by custom over which no authority is asserted, so that invention here is practically prohibited for centuries.

[20] Our 16 different institutions for the support of invention are measured as to their respective financial outlays for it, as mentioned, the real contribution of the freelance and the minor, personal firm being proved very small, around 2%. The merits, limitations, and best fields for each of the institutions are taken up in chapter 10. A new institution is proposed in chapter 11, which the author reasons would avoid almost all the shortcomings of the existing systems, and support invention much better than ever before, with unlimited funds, and guidance for social welfare, yet with direction by businessmen, through licensed, nonmonopolistic, semipublic trade associations, which would acquire universal membership through gaining control of all the good patents, through being granted them on better terms than to noncooperating inventors. Thus, all the best inventions could be used by as many producers as ought to, combating monopoly. There would be no royalty tax on novelty, whatever laboratories were most suitable would be used, and unorganized and foreign inventors would be fairly dealt with and encouraged according to their merits, by these associations with public spirit and ample funds. The associations would enjoy unlimited funds to support invention and research, because their membership dues would be simply passed on to the consumers on all goods novel or old, produced by the industry, as with other business expenses.

[21] Finally, our last two chapters take up the nature and nurture of invention, chiefly through the attention to their psychology, intensely cultivated of late through our Government. With the related questions of how to make scientific discoveries and successful innovations in all fields, this problem of *how to discover* may well be called the most important problem in the world; because in solving it we unlock all the doors to progress, in every direction. While citing the findings of hundreds of recent researchers, attention is centered on the ambivalence of knowledge—how for the baffling inventions the inventor both needs to be informed on all the prior attempts and available facts, and on the other hand is undone by this knowledge, which tends almost ineluctably to lead his mind along stale paths. Various escapes from this dilemma are discussed.

[22] In the final chapter the claim is made that although most of our inventions must come from engineers, the undergraduate engineering curriculum, and the older, typical life scheduling for engineers, are grievously anti-inventive, teaching distaste for the word *inventor*, and barring all exercise of the inventive faculty until middle age, by which time it is likely stultified for good. Our best remedy were to learn better about the many traits found to characterize creative talent (for invention and other fields) at early age, protect the boy who is a potential discoverer from the crushing, homogenizing tendencies around him, give him special schooling, especially in the case of engineers, and deliberately teach him the art of Invention.

CHAPTER 2

A THOUGHTFUL HISTORY OF THE PATENT SYSTEM

[24] The origin of the patent system is often set down, especially in the older literature, as starting from the English Statute of Monopolies, in 1623, which struck down monopolies granted by James I for his private purposes, but allowed such as we have under the patent system. However, the real origin of our system is much older. There were sporadic examples of patents in ancient and medieval times,[3] and the system was regularized, essentially in its modern form, by a statute of the republic of Venice in 1474, which reads:

1474, March 19

[25] WE HAVE among us men of great genius, apt to invent and discover ingenious devices; and in view of the grandeur and virtue of our City, more such men come to us every day from divers parts. Now, if provision were made for the works and devices discovered by such persons, so that others who may see them could not build them and take the inventor's honor away, more men would then apply their genius, would discover, and would build devices of great utility and benefit to our commonwealth. Therefore:

[26] BE IT ENACTED that, by the authority of this Council, every person who shall build any new and ingenious device in this City, not previously made in our Commonwealth, shall give notice of it to the office of our General Welfare Board when it has been reduced to perfection so that it can be used and operated. It being forbidden to every other person in our territories and towns to make any further device conforming with and similar to said one, without the consent and license of the author, for the term of 10 years. And if anybody builds it in violation hereof, the aforesaid author and inventor shall be entitled to have him summoned before any magistrate of this City, by which magistrate the said infringer shall be constrained to pay him a hundred ducats; and the device shall be destroyed at once. It being, however, within the power and discretion of the Government, in its activities, to take and use any such device and instrument, with this condition however that no one but the author shall operate it.[4]

[27] From Venice the patent system followed the trade route to Germany, and reached England in 1561. The first fully recorded and preserved patent went to John of Speyer who introduced typography to Venice in 1469. It is noteworthy that the patent system arose simultaneously with the printing art (whose great early center was Venice), and with the institution of copyrights, and that patents and

copyrights have ever since been closely associated in law and lawyers. Indeed, it looks as if copyrights were the precipitating origin of patents, and the similarity and difference of the twin institutions reveal why copyrights are in full vigor and expanding to this day, while patents are declining and under heavy attack. The two are alike in granting a monopoly for a main purpose of rewarding creativity, and a minor purpose of saving overhead through concentration of manufacture. (¶ 156ff.) (Patents have additional minor motives also, such as obviating secret working.) The two institutions are also alike in their drawbacks; monopoly, interference with the public's freedom and its possibly important interest; and the difficulties of defining the protected matter, determining its true author, and protecting it from copiers. All these difficulties are graver for patents than for copyrights, and have been becoming still more so for the last century; and secret working has probably become less possible. Later chapters will support these statements, and also mention that copyrights may shortly face new and notable difficulties. (¶ 35.)

[28] The original Venetian patent law of 1474, above copied, is the gist of American patent law today, with only the following changes of any importance:

1. A complete description of the invention has come to be required, and began to be published about 1710.

2. Patenting has been changed from a duty, later a privilege, to a right; i.e., an inventor can sue to force grant of a patent.

3. The requirement of usefulness has been reduced to mere operability, by American practice in spite of American statute law.[5]

4. A shift in emphasis, from introduction into the realm, to invention in the modern sense.

5. The patent term has been lengthened somewhat, from 10 years in the Venetian original to 14 or 15 commonly, and in America to 17 from the date of grant. This in turn starts (in the U.S.) 1 to 10 or even 20 years after the date of application, according to delays arising in the Patent Office and/or fostered by the applicant, the average delay being today nearly four years. Another year may be added, of publicity or use before application, making a total of 18 to 30 years or so, of patent coverage (the average 21) determined by chance or lengthened by scheming.

[29] In its earlier history the patent system often took on the functions of encouraging the importation of foreign industries, or of serving the king's purse; but these excrescences have been sloughed off, and a modern one of industrial monopoly often added. Hulme,[6] from his study of patent statistics (from which we have compiled table 1) observed that some growth of patents from 1660 to 1700 was not

[5] Since Justice Story "useful" has been taken to mean not mischievous, immoral nor inoperative. Stocking & Watkins, N 253.

[6] "The Patent Office does not pass judgment on the utility of the patents it grants." F. B. Jewett, president of Bel Tel. Labs., quoted by Wilson, N 201, his p. 181.

TABLE 1.—*English patenting, 1552–1960* [1]

Period	Patents per decade	Per million population	Period	Patents per decade	Per million population
1552–1671	26	5.1	1852–1881	25,031	1,006
1672–1761	68	11.5	1882–1901	103,974	3,113
1762–1791	359	46	1902–1911	155,118	4,432
1792–1821	929	94	1912–1921	131,675	3,150
1822–1851	3,086	200	1952–1960	207,200	4,170

[1] From Hulme, our N 6, his chart 2, condensed and supplemented by later data. Populations of England and Wales used to 1851, and of Great Britain for 1852 ff.

maintained in the following 40 years, and their period of real flourishing began in 1766, just before the epoch-making inventions of Watt and Arkwright. We may call this the best starting date for the Industrial Revolution, if not 1770. Federico says [8] that not until the mid-1700's did patents encourage invention.

[30] Search to verify novelty before granting was begun for America in 1836, and is still not used in the Latin and the backward countries, though France is starting to introduce it, cooperating in searches with the Low Countries (¶ 440). We cannot see search as of vital importance, since no country has tried to do it thoroughly, and our own examiners can give but 3 man-days, on the average, to searching the world's literature before granting or refusing a patent (¶ 295). Only a patent lawsuit, or several of them, can bring out the truth, and not always then, since litigation in this field, as elsewhere, involves some margin of error and some resolution of controversies on grounds of expedience rather than of the merits. Indeed, there may be a higher incidence of such factors in the patent field as a result of judicial failure to understand the inventions and prior art presented to them, and of the disposition of owners of doubtful patents to settle on such terms as they can get, rather than persist in litigation at the risk of having their patents declared invalid.[9] Statistics show that only 11.4% of the cases filed go through to a contested verdict. (See ftN *263*, p. 86.)

[31] The patent system spread all over the world, including colonial America, but there as in other industrially backward lands it had small importance, at least as a stimulant to native invention.[10] It was taken into the United States Constitution along with copyrights by the clause "Congress shall have power . . . to promote the Progress of Science and the Useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." Custom is obligatory that this clause be quoted; yet it would seem to have little significance for us, first because it was adopted without a dissenting vote, indicating that the Fathers simply meant to take over the long-existent patent and copyright systems whatever they were. Secondly, we do not lay much stress on the quoted words, because they have several times in the past been stretched

[8] As in one of the principal Bell telephone cases, as charged by the Government and never adjudicated. Sylvester Petro: Patents; in *U. of Chgo. Law Rev.* 12: 80–103 & 352–420, 1944, 5 esp. p. 371; or Hamilton, N 207, pp. 87, 8. The legal history of patents in England and America may also be read at length in Hamilton, his pp. 11ff.

[9] No American invention of importance was patented until 1790, and scarce any made. The negligible contribution of the backward countries in 1923 is demonstrated in Gilfillan: Inventiveness, N 51.

in the private or public interest [11] without constitutional protest, and could be stretched again in the public interest, if need appeared. The patent system is not a law, but an ancient and worldwide institution, a very stable one, yet modifiable.

[32] Throughout the world the system has an unusual degree of uniformity, with ownership nominally for around 16 years, all other features being of much less importance than the multifarious institution of private ownership. Inventors have full liberty to patent in foreign countries on equal terms, there are international conventions and a little recognition of other nations' patents, and one would seem to see a sociological basis, in similarity of habits and purposes, for international patenting, like the achieved international copyright. Potentially a vast convenience, it is at last being advanced in Europe (¶ 495).

[33] Let us glance at what differences there are between the American and foreign patent systems.[12] Frost [13] says "It is no accident that the nation with the strongest patent system is also most dedicated to the principles of competition." Many call ours the best patent system in the world. It may be; yet also it is the most archaic. It is the most elaborated in its details, rigid as to claims,[14] and perhaps the most restrictive as to inventive grade; and yet in its essence it is the simplest, the least changed of all of them from the Venetian statute of 1474, and also the most favorable to the patentee. Unlike foreign usage, an American patent runs for 18 to 30 years or so, delays included, as we said above (¶ 28). There is no way it can be revoked, unless by an unsuccessful infringement suit. The patentee chooses his time and court for any fight, unless the defendant can first get a declaratory judgment against the patent, and we have the peculiar feature of Interferences, found only in American and Canadian law. This means that when two or more patent applications are found in the Office at the same time, or one is even filed within a year after a patent issues, covering more or less the same invention (which happens fairly often, with our long pendency) the Office summons the parties to fight out the question of which had the duplicated idea, or its various steps, first. The interference procedures established by the Patent Office are particularly complicated, last 4 years on the average,[15] or longer if carried to court. Interferences probably involve about 2½% of patents applied for, one-third of the time involve an issued patent, and are increasing at 29% per year. In 1960, interference involved 3,128 patents, 1.4% of those pending, 6.2% as many as in a year's grant. All other countries give the patent to the first applicant, unless theft of the idea can be shown; and he wins 80% of our own contests.[15]

[34] A number of additions to the simple, original patent principle, that used to be found in the American statutes, have been eliminated, our law of 1836 remaining otherwise almost unchanged. We dropped off renewal of patent, caveat (warning that one is working on an invention), compulsory license (once briefly in our patent law, and today abundantly ordered in antitrust decisions), and discrimination against foreigners. Contrastingly most foreign countries formally provide for compulsory license under certain circumstances, such as

[11] By granting a host of patents which do not "promote the Progress of Science and Useful Arts", and plant patents, and by taking patents for public use, and enforcing cancellation or licensing in antitrust cases.

nonworking in that country; publication of applications with invitation to oppose them, nullity or revocation proceedings from the government or rivals after grant, coterminating patents of addition, admission of some old ideas to patent, petty-patents in Germany, of brief term and low requirements, and taxation of patents after the first few years, at rates increasing periodically, with the aim of clearing out the obstruction of unused, trivial, and invalid patents, while preserving their informative value, with the result that 97% of German and English patents and 97–95% of Dutch are cut short.[16] We shall take up later (chs. 5, 7, and 11) the theory and merits of these modifications of the original patent system. But none of them greatly modifies in practice the ancient Venetian essence of the patent system, that an inventor may own his idea for about 15 years.

[35] It is curious that an institution 490 years old, and preserving in America its oldest surviving form, should be thought of as our only actual or possible means for stimulating and directing invention. For invention is most typical of the modern age, one of the ever newest things on earth, its very essence being novelty and incessant change. In these respects invention's only rivals are science, and other forms of innovation. We are similarly concerned to promote all of these; so how would it be if we search through the statute books of the 1400's, to find some bit of legislation for Science, and adopt that in essence, but with modern detail, to be our main formal instrument for the maintenance and directing of science today? It might still work, you know, but we should rather expect it to fit modern science poorly, and increasingly badly as the centuries pass. This argument does not condemn, it only looks askance. Patents' twin brother Copyright still works very well—because the production of copyrighted matter is still done in the same way, economically considered, as it was in Renascence Venice, viz., with the expenses largely prime costs, and the protection easy (¶ 27). But Copyright may get in trouble shortly, now that copying devices of various sorts, for photographing or recording sights, texts, and sounds, are becoming easy, cheap, and ubiquitous.

[36] For patents to have survived the centuries as well as they have, we may find several reasons. In the first place the institution was born two centuries prematurely. Depending for invention on long views, risk-taking and inventiveness by nearly illiterate craftsmen-enterprisers, usually of small capital and rank, it evoked few inventions, was of little help, for its first 2 or 3 centuries,[17] until the Industrial Revolution and the rise of wealthy and intellectual capitalists and educated artisans gave the patent system a *milieu* adapted to it. Nowadays, when invention finds itself in a third sort of environment, one of science, great corporations, great laboratories of cooperating specialists, great governments and war preparations, the system no longer fits so well, of trying to date inventions and ascribe them to particular individuals, to whom are given all the full negative right of ownership, the right of blocking others from using the invention.

[37] Indeed, a second reason why the patent system has survived five centuries as well as it has, while many other Renascence laws are to be found today only in libraries, is certainly inherent flexibilities about it. It gives the patentee all the freedoms of ownership to use, disuse, sell or lease in parcels his rights on any terms found suitable. And while his rewards can range from millions down to (very often) zero, there is an automatic tendency for the reward to have

some vague proportional relation to the service he rendered. Finally the patent system is itself not exclusive or monopolistic, in the way that governments, religions, and marriages can tolerate no rivals. Patents exist side by side with, or cooperate perfectly well with their rival institutions—unpatented inventing, government inventing, awards, patent pools, or monopolies, which reject, or change the significance of patents. And so the rival institutions have for the most part replaced the patent system, as we shall prove, so quietly that hardly anyone realizes what has happened.

PATENTS COME TO BE CRITICIZED AND CANCELED

[38] The patent system is accepted throughout the world, as we have said, save naturally in the so different economic *milieu* of the Soviets. There it is replaced by a system of awards to inventors, and by government inventing chiefly of course, and by the mere name of patents, a ghostly remnant latterly emphasized, and by a special government organ to stimulate the use of new inventions. In western Europe a wave of protest against patents arose [18] at the height of the *laissez-faire* period about 1865, which led Holland to abandon the whole system from 1869 to 1910. Sentiment critical of the system, but never proposing its abolition, has grown up in America since about 1910, coincident with the rise of modern economic liberalism and opposition to monopoly, and especially right after the Temporary National Economic Committee's inquiries of 1941. The movement has produced insistent proposals for such changes as compulsory license of patents, and hearings, bills in great number, and two or three commissions of inquiry. But no reforms of importance have yet been enacted, nor many legislative changes in our patent law of 1836. What amendments have been made in these 127 years have been mostly of minor, technical, procedural nature, or gave up substantive additions to the patent law of 1474, as aforesaid. Some legislated changes to be mentioned are that all patents of Federal or (at first) of atomic significance have been made subject to expropriation, which amounts to compulsory license; and there has arisen an expanding use of declaratory judgment proceedings.

[39] What really important changes have come in the patent system, aside from its wholesale replacement by the rival institutions, have come not through legislation, nor administrative order, nor by voluntary action of the professions, Congress or political parties, but have been forced upon the system by the Federal courts in recent years, in the modern atmosphere of opposition to monopoly. We refer not only to the system of compulsory license which the courts have lately been establishing in successful antitrust and misuse cases [19] (sometimes with free licenses as a heavier penalty), but also to the courts' growing habit of throwing out individual patents, so that now only a one-fourth minority survives a full court test. Table 2 and Federico's studies [20] show how, among patents litigated to a contested and published decision, the percentage destroyed has gone from 62.3 to around 75 in 1948–54.[21] Still another study,[22] from 1938 court

[21] Considering that a large part of the patents from the district courts were appealed, we have given equal weight to the percentages of the lower and the appeal courts. Federico's study, N 20, prepared at the request of the Senate Subcommittee on Patents, provides numerous tables, covering the courts of appeal and the Supreme Court from 1925 to 1954, in some ways better than our own table. Other data are in the Subcommittee's *An Analysis of Pat. Literature Stat.*, ftN 269.

trials, found 38% upheld, of 239 cases. Latest data of Mayers [22] indicates about 28% of patents being preserved in force by the Circuit Courts of Appeals, with perhaps a small rise since 1942, visible also in Federico's table,[20] but only 13% in 1955.[23]

[40] TABLE 2.—*Fate of litigated patents, 1929–54*

[Adapted from Federico, Evans, Lang & Thomas, as per the citational notes. "Percent upheld" refers to the patents held valid and infringed, in the remaining cases the patent having been either invalidated, or held not to be infringed; unknown or split cases are excluded from the comparison]

	1929–34 [24]		1936–41 [25]		1940–44 [26]		1945–49 [26]		1948–54 [20]		
	Patents	Percent upheld	Opinions	Percent upheld	Opinions	Percent upheld	Opinions	Percent upheld	Suits	Patents	Percent upheld
Supreme Court	22	21	15	0	15	15	10	30	7	7	20
Circuit courts	871	31	462	19	602	18	256	22	310	449	18
District courts	1,967	71	------	n.d.	750	36	311	37	461 p 223 u	664 p 334 ue	30 p ftN [27]

p=published decisions, u=unpublished decisions, e=estimate.

[27] "Indications are that complete district cour. data would show a higher percentage valid and infringed and a lower percent invalid." Federico, N 20, his reprinted p. 241.

[41] An American patent may be invalidated for various reasons, but nearly always the adverse verdict includes "want of invention" or "anticipation." "Want of invention" means that the new idea was too logical or easy to come upon, in view of the "prior art" (what was known before the application date), to be worthy of a patent which would deprive the public of the right it held before, to turn up and use the idea. We shall discuss this principle of the minimum level of patentability, in the following chapter. The remaining invalidations were from discovery of a prior public use or publication of the idea, or from inoperativeness, lack of disclosure, or other defects of procedure.[28] A finding that a patent is not infringed, which our statistical sources distinguish from a finding of invalidity, and show to be slowly decreasing, until it is today a third as frequent as invalidity, has much the same effect as invalidity. For it entails that the patent can be avoided by anyone using the same technique involved in the suit, even if not so conveniently. A finding of noninfringement impugns not the Patent Office (unless for accepting an ambiguous claim), but likely the patent system, since it may mean that a method inferior to the best known has been forced into use, and anyway, a useless struggle entailed.

[42] We may note from table 2 that the higher the court the higher the proportion of patents that lose; and observe the slow tendency above referred to since 1925 or earlier, in the courts of all levels, to eye patents more balefully, till three-fourths of all that undergo the ultimate test leave it dead or wrecked. But there may be statistically discernible a slightly more lenient tendency since 1942, perhaps reflecting better patents and fewer suits.

[43] We may note also the high proportion of the cases appealed to the Circuit Courts of Appeal. Few get to the Supreme Court, which is reached only on a writ of *certiorari*, usually granted only when two Courts of Appeal have disagreed about a patent.

[44] Our sources further show wide differences in the attitude of the several circuit courts, and therefore in the district courts subject to each, ranging in 1948–54 from 37% of patents upheld in the 4th and 5th Circuit Courts, to only 2.6% in the 2d, the New York circuit.[29] In consequence, complainants naturally try to bring suit in the favorable circuits.

[45] Whether the courts are too severe is a question, in view of the admitted low quality of patents. We shall take up later (¶ 292–300) why the Patent Office is unable to impose higher standards of patentability.

[46] With only about 1% of our patents ever getting a contested court decision, we have to guess from this special sample as to the strength of all patents, and the impact of court decisions upon all. The 1% litigated are all doubtful cases, since a patent that was either clearly valid or clearly bogus or inapplicable would ordinarily not be fought over, and least of all appealed. And they represent inventions of value, either intrinsically or because useful to attack a weak rival firm or inventor. From this selected 1%, of inventions valuable for some reason and of doubtful validity, we have to judge the viability of the other 99%, since there is no other index. Perhaps the best guess is that these patents are rather typical of the rest that matter.

[47] One other lesson of importance is clearly to be read from table 2. The amount of patent litigation has latterly been falling off, notably as counted by patents contested to an appeals court finish.[30] These were 649 in 1925–59, rose to 803 in 1935–59, or 0.4% of the patents granted in those years, and fell to 336 or 0.16% in 1950–54. The *reasons* for less legal fighting are not hard to imagine. The decline in number of patents granted since 1925–29 would account for 6% of it. The probability, which has risen 3 : 1, that the patentee starting and pushing through a suit will lose it, would inevitably be a factor. The progress of patent pooling, and informal comity between competitors, and compulsory licensing to the Government and others, indeed all the basic factors making for decay of the patent system, would probably cowork to reduce the amount of litigation, which will be discussed again in ¶ 263ff. An exception might be the probably rising share of suits which are brought by alleged infringers under the Declaratory Judgments Act.

Chapter 3

MEASURING INVENTION AND THE DECLINE OF ITS PATENTING

[48] A remarkable and nowhere sufficiently appreciated decline has been going on for the past 78 years, if not longer, in the proportion of inventions that are patented. We have already seen anent table 1 and its source how British patenting once expanded rapidly, albeit with a slackening rate of increase after 1766, and reached a maximum per capita rate in 1902–11.

[49] In America from 1880 to 1934 the number of patents granted only kept pace with population, as shown in chart 1. (We have here eliminated patents granted to foreign residents, which have risen to 17%.)[36] Since 1880 our annual grant to Americans has fallen to 40,154 in 1961, or 219 per million of population. In 1879–81 they averaged 12,726, or 254 per million, a per capita rate 16% higher. Surely per capita *inventing* has not fallen off since that remote and bucolic date, but must have much increased. In 1880 49% of American workers were farmers, compared with 4.8% in 1962.[37] There was then but one tiny invention laboratory in the Nation, and the electric and chemical ages had scarcely begun. The difference between America then and now is like the difference between South Dakota and Connecticut today, which we find accompanied by a 10-fold difference in per capita patenting, and therefore presumably in frequency of inventing. Yet patents per American capita have declined.

[50] But if we wish conclusively to prove and measure the decline of patenting relative to invention, we must seek measures of invention, to compare with the patent counts at hand (chart 1). An historigraphic index of the progress in yearly quantity of inventing in America would be of wider interest, too. Because of its difficulties none has ever been offered for recent decades, based on anything but patents,[38] an obviously shrinking tape, and incapable of measuring its own significance, or on worse evidence, or on statistics based on some of the evidence which we shall work up with much more care, elaboration and historical extension.

[51] Hart has interestingly measured over the centuries inventive progress in particular fields,[39] such as speed of travel, distance of fighting, longest bridge spans, and speed of cutting tools, but without enough such parameters to compose a general index. Economists [38] have sought to measure general technological progress; but this is by no means the same as measuring American inventing. For progress, and productivity, depend on many other things—the use of old inventions, the importation of foreign ones, innovations other than inventions, blunders public and private, the supply of capital and land, the discovery or the exhaustion of resources, the education and quality of labor, the losses through unemployment, strikes, war and military out-

lays, old age retirement, and on many other factors. It seems doubtful that any statistical economist could so well measure and remove all these factors as to reveal more about American inventing than we know already, viz., that it is important and rapidly advancing. But for what it may be worth here, the Gross National Product is stated as growing by 40% per decade since 1929, and 60% per decade since 1939,[40] and has been said by W. C. Mitchell to be always underestimated.[41] Real income per capita increased 4-fold in 1870–1950. Brozen considers [43] that our yearly rise in productivity per man-hour in the nongovernmental sector has been 2.5%, assigned as due 1% to increased capital, ¾% to improved allocation of resources, such as turning to manufacturing instead of farming, and ¾% from better science and improved technology. This in effect assigns three-tenths of such improved productivity to invention. But allocation of resources could not be improved without invention, e.g., by improvements in the productivity of factory labor. Solo would ascribe 90% of the rise to technology.[670] We have graphed two indices of the productivity of labor on chart 1.[44]

[52] Others attempting to measure invention have drawn up long lists of great inventions, and counting those dated in each quarter-century or longer period, have sought to compare the epochs.[45] The method may serve for distant centuries, in lack of a better way, and we have tried it on our problem of 1880 to date, but with total failure. The best such published list for modern times is probably Streit's [47] of "1012 major inventions, discoveries and innovations since 1750," carefully prepared from previous lists, checked by experts, dated, and showing that 97% have been made in the countries proposed for Atlantic Union. But a count of the inventions and discoveries indicates no change in America's output since 1880, a manifest error. Trying the same on my own unpublished list [48] of 500 socially most important inventions since 1782, from all countries, a decline of a fifth was read between the periods centering at 1885 and 1914. The trouble with all such invention lists when brought down to recent times is, first, that they are highly subjective, based on certain people's impressions and memories; and it seems likely that we can understand and appreciate better the simpler inventions of bygone times, than the highly technical ones of latter days, save those in some field we may be versed in. We can view the past as historians, but recent times only as specialists. Secondly, it takes many years for inventions to be often recognized as important,[49] (¶ 330) always 20 or more years (the average, 40 or so), sometimes centuries, between the date apt to be given the invention (its first operative or commercial success), and the date when it becomes recognized by all as an important invention. The great, fundamental inventions for the future,

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[41] Comparing the period 1869–78 with 1944–53, M. Abramovitz reports a rise of 13.25-fold in the net national product, 3.34-fold in population, and 3.97-fold in product per capita, making an annual growth rate of 1.9% in this last, and 3.5% in the net annual product. The rates of growth seem to be falling off somewhat. *Resource and Output Trends in the U.S. since 1870,* Occasional Paper 52 of Nat. Bur. of Ec. Research, 1956, 23 pp., esp. pp. 7, 8. Cf. also Markham, N 38.

[47] Streit, C. K.: *Freedom Against Itself,* Harper, 1954, pp. 239–72. The primary inventors and their countries are named; but the cogent argument for Atlantic Union is not helped by assertions that freedom alone has been responsible for northwestern Europe and the U.S. producing practically all the world's inventions and discoveries in modern times. It is too easy to cite exceptions, of nations unfree, yet inventive; and the *geographic,* historical and possible racial factors must not be ignored.

which we shall discuss in chapter 8, such as the voice-operated writing machine, or the wholesale fractioning of air and sea-water, all have their starting dates already in the past, yet they would not appear in those lists.

[53] A third, and perhaps most important consideration, is that inventions are probably evaluated by comparison with their contemporaries, and as there are always leading inventions in each period, we would tend to see a constant frequency of them in all the ages. Thus, e.g., the power loom [50] is rightly recognized as one of the great inventions of the early 19th century; but when the like is devised today, in frequent mechanizations of simple operations formerly done by hand, we do not recognize in these any great invention, nor add them to a list of the important inventions of the 1960's—we notice simply a swarm of mechanizations. We shall speak again (¶ 103) of this principle after completing our new indices of inventive effort and success, and must now abandon this method of seeking to count important inventions, and find better approaches to the much desired index of invention.

[54] However, a useful purpose can be served by such lists, in the comparison of one nation with another, at a given epoch and down through time, since the inventions will be compared with their contemporaries. Thus, Streit's list (see ftN *47*) gives America 37% of the world's inventions and discoveries made in 1880–99, rising to 54% in 1930–39, and to 88% in 1940–50. The statistical basis is rough, but the finding may be of interest. (Cf. ¶ 89.) Another study,[51] based on patents with statistical precaution, shows the U.S. in 1925 contributing something over 15% of the superior patented inventions. Federico [52] and Sanders [53] supply some modern data based on patent applications. Cf. also ¶ 86.5.

How One Measures an Economic Complex

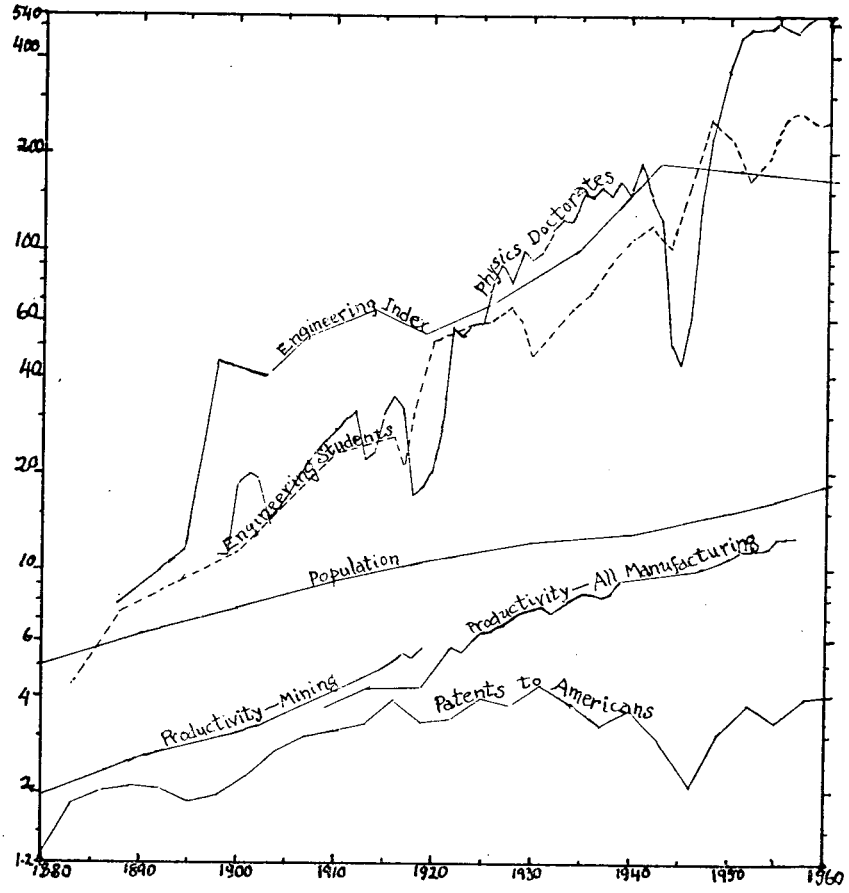
[55] When one seeks to measure the importance of any multifarious social phenomenon, like war or entertainment or education, one will probably go at it by reckoning the money spent for it, on the assumption that it is worth about what people pay for it—or else by counting the man-hours devoted to it. Only the latter were better to be not a crude count of man-hours, but weighted according to the value of the man, which varies widely. So let us apply these same two measures, of the cost and the weighted man-hours, so well as we can, to the measurement of invention. We cannot find statistics completely to our point—one never can—but we can at least find fair *indicia*, variables that should be concomitant and commensurate with the inventing we seek to measure.

[56] "Money makes the mare go" is an old proverb, and it is truer than ever when we substitute for *mare* the airplane ticket, laboratory, and all the host of researchers salaried from public and private treasuries, that are necessary for most modern invention. The amount spent on organized inventing, by government, industry, universities, foundations and all other organizations large enough to have a laboratory, for

[50] By de Gennes in 1678 and by followers, more importantly by Cartwright in 1788 ff., and little usable until well in the 19th century.

CHART 1

INDICES RELATED TO AMERICAN INVENTING, 1880–1960

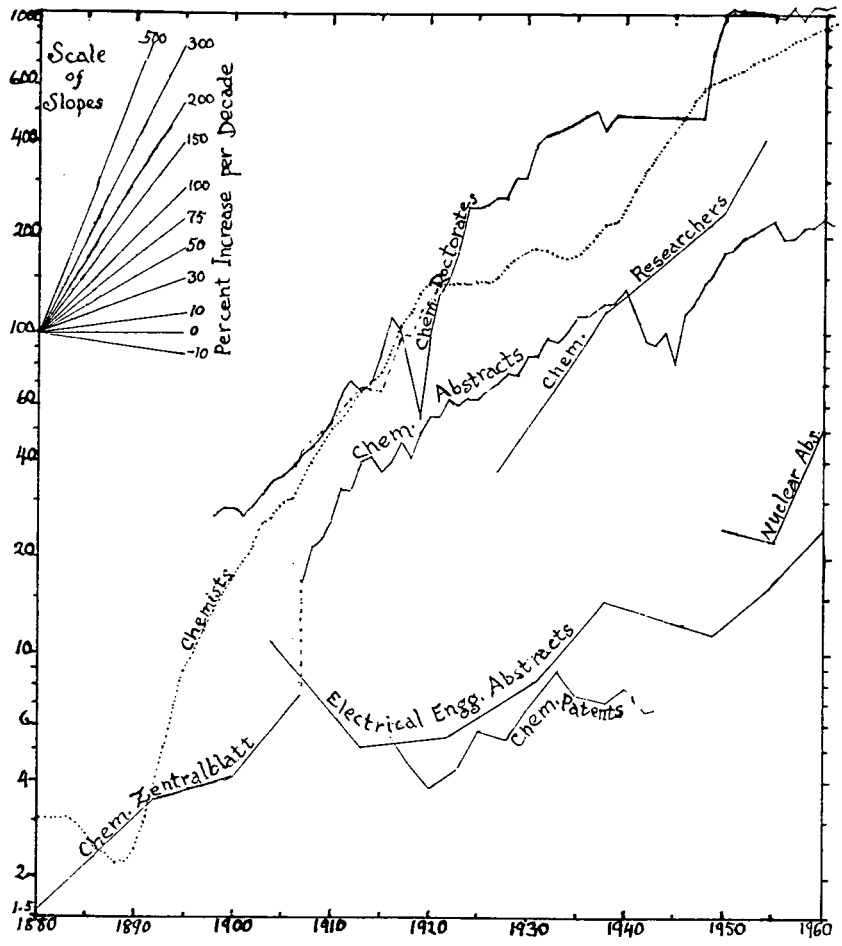


invention or development or for such research as is usually invention-oriented, or else likely to be soon utilized for invention—all this flood of gold should be transmuted yearly into a flow of inventions worth more to the paying authority than their cost—or else the principles of economics are wrong, and a host of business leaders and highest Government officials have been buying billion dollar blunders for years. So we have plotted on chart 3 the funds provided for organized research and development by the Federal Government,[55, 56] and by com-

[55] Estimated expenditures by the Fed. Govt. for scientific R&D for the fiscal year 1962 was $10,172,200,000, including military personnel and procurement funds and increase of plant for R&D. This is in contemporary dollars, not stabilized dollars as in chart 3. While serving some purposes of science, agriculture, etc., unrelated to invention proper, these expenditures for R&D were 92% for the military, aeronautical, mining, postal, and other offices whose research we assume to be invention-oriented, viz., $9,387 million. Or divided according to character of work, the obligations for conduct of R&D in 1956 were allotted as 7% for basic research, 31% for other research, and 62% for development. Divided by scientific fields, the 1956 funds for research went 54% to the engineering sciences, 18% to the physical sciences proper, and 28% to the life, agricultural, and mathematical sciences. For sources see N 56.

CHART 2

VARIOUS INDICES OF AMERICAN INVENTIVE EFFORT, ESP. CHEMICALS, 1880–1960

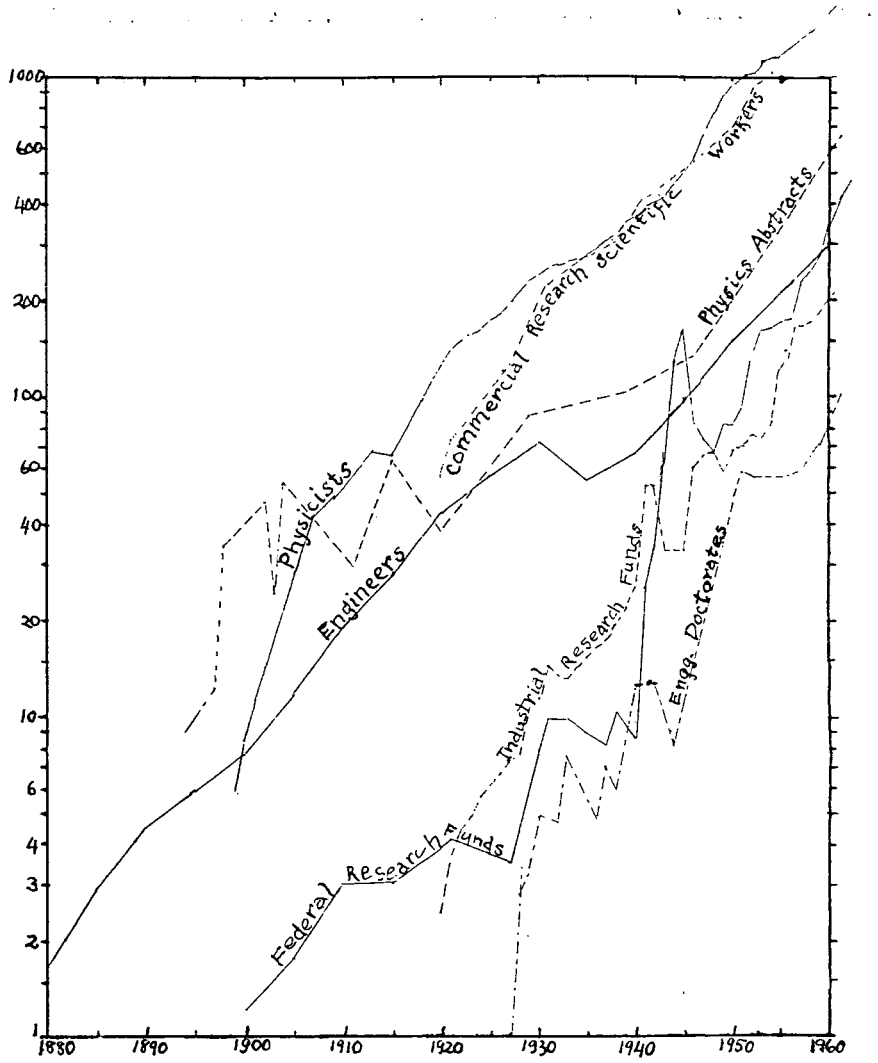


mercial industry,[57] as far back as data can be found, all restated in dollars of stable 1938 consumer's value.[58] While these data are somewhat shaky, especially in their earlier years,[59] the chart reader can see that even if some figures ought to be doubled or halved, this would make little difference in the slope of their graphs.

[57] Confirmation for these historigrams, and a better measure of invention, bypassing the problem of an appropriate price index,[58] is afforded by the counts of professional grade workers in industrial research [60] (chart 3), since 1940 often working on Government contracts, and of chemical researchers [61] in the chemical, petroleum and rubber industries, a subclass of the preceding, on chart 2; and best by our graph of all organized research professionals (on R&D, governmental, industrial, university, and others), shown on chart 4.[62]

CHART 3

FURTHER INDICES OF INVENTIVE EFFORT, 1880–1960

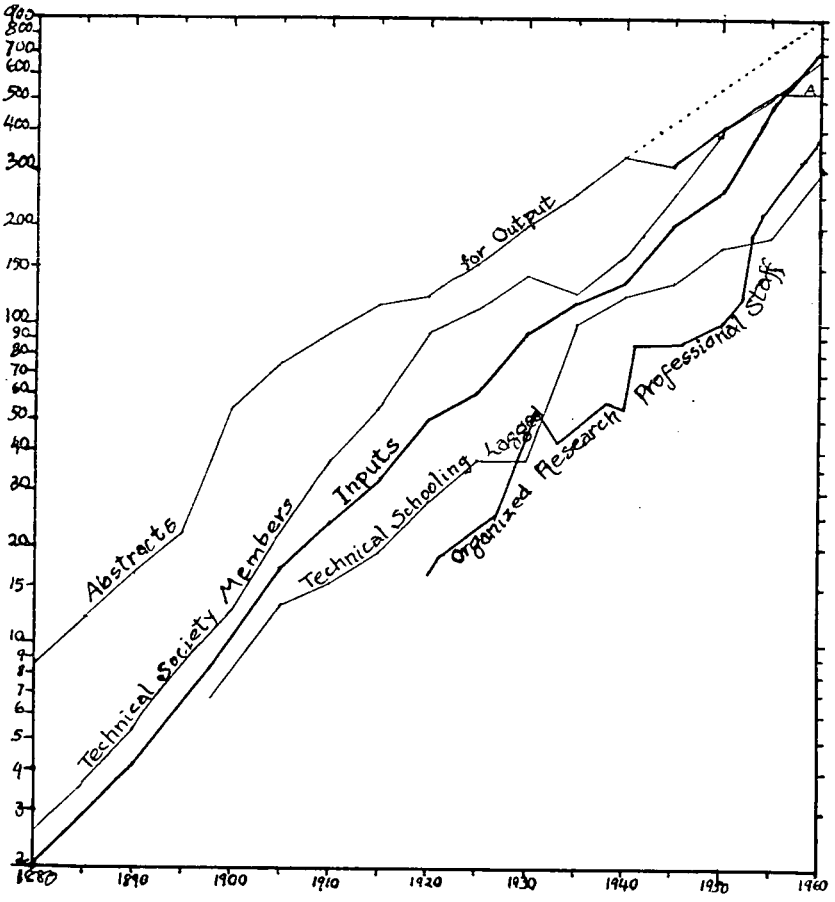


[58] These professional-grade workers have the important assistance of a staff of lower rank—draftsmen, electricians, mechanics, translators, clerks, helpers, etc. And this helpful staff has been increasing, from 35 per 100 professionals in 1921, to 178 in 1957 including 53 technicians in 1960.[63] These important, growing supplements are not reflected in our graphs, and would warrant steeper slopes than drawn.

[59] Even without this growing assistance from their humbler helpers, the count of professionals in laboratories has been doubling in each decade, from 1920 to 1953, and faster recently. The rates of

CHART 4

CLASS SUBTOTALS AND INDICES OF INVENTIVE INPUTS AND OUTPUT, 1880–1960



change in each of our graphs may be figured from the margins, or by comparing the various slopes with the Scale of Slopes in chart 2.[64] Melman uses similar data as a measure of invention, versus patents, observing that the country's scientists and engineers rose to 1.8-fold per decade since 1900, and the research ones to 3.2-fold per decade in 1941–54.[65]

[60] For another means of measuring invention, this time by its *output*, instead of by the input, of efforts to invent, suppose we try again to count inventions and pertinent discoveries. We shall not depend on the judgment of a dozen or so of our own contemporaries looking back over the 83 years past, but on the assessments of hundreds

[64] Our charts were all drawn on identical and familiar ratio-chart paper, which plots time normally, and the vertical quantities by their logarithms, so that the same change of height, or the same slope, always represents the same proportional change or rate of change, wherever it occurs on any chart. Absolute magnitudes may also be read off from the margins, with the decimal point and the definition of the unit obtained by consulting the citational note where each index is first mentioned; this note quotes in its last words the initial or the final quantity.

of thousands of technical writers, editors, and abstractors, who were contemporaries of those inventions and discoveries, throughout the whole epoch. We have sought to do this in charts 1–3, by counting the abstracts of scientific papers that seem to have been authored by Americans, mostly on inventions, or chemical or physical discoveries such as lead to inventions, published since the several starts of the international journals of abstracts, *Chemical Abstracts* [67] and its older German contemporary *Chemisches Zentralblatt*,[67] (chart 2), likewise *Physical Abstracts* [68] with its predecessors (chart 3), *Electrical Engineering Abstracts* [69] (chart 2), *Nuclear Science Abstracts* [666] (chart 2), and *Engineering Index* [70] (chart 1). It might be objected that these notices on articles, just as with patents, deal mostly with unimportant inventions and discoveries, and often repetitiously, rather than with the few important inventions. Actually, a great invention or discovery always attains expression in a multitude of minor items, so that repetition helps us by weighting the important. And we think that repetition is likely to be a factor fairly constant through time, and therefore permissible to ignore.

[61] To the foregoing tallies of reports on inventions and discoveries, and of the men and money devoted to making them, let us now add three counts of the men training to man the inventive professions. We can find data on three types of students who can probably serve as fairly good indices of the whole, data sufficiently uniform and going back to 1883 for Engineering Students [71, 72] on chart 1, Engineering Doctorates [73] conferred only since 1922, on chart 3, Physics Doctorates [74] conferred, on chart 1 back to 1899, and Chemistry Doctorates [74] on chart 2. Such men are largely inventors, as we detail in ¶ 63. Since our preparation of these data Blank and Stigler [77] have presented much more on the education and census counts of our technologists, by year; and Melman [65] as noted (¶ 59) has used professional counts from the Census and reports on research and development, for comparison with the rate of patenting.

[62] Finally, let us add indices of the sorts of men working to produce most of the inventive progress, viz., the chemists, on chart 2, represented by the membership of the American Chemical Society,[79] the physicists [80] in the American Physical Society (chart 2) and the engineers. For the last we have added together on chart 3 the members of the five oldest and largest engineering societies.[81] Such men are presumably a more intellectual and inventive group than those belonging to no major society. Our five associations are the American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, American Institute of Chemical Engineers, and the Institute of Electrical and Electronics Engineers, including its two principal predecessors, the American Institute of Electrical Engineers, and the Institute of Radio Engineers. These include altogether about 340,000 of the 875,000 engineers estimated to be in the country.[82] We hesitate to use the Census counts of "engineers" because of doubt about what the word meant in each decade.[83] The omission of the 130

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[71] Engineering students as well as doctorates were counted because the last degree was not awarded until about 1910.

[83] The 1950 census reported 261,428 engineers in the experienced labor force, and 245,288 so employed, while the subtotals for experienced civil, electrical, and mechanical engineers were 2.47 times greater than for the three corresponding societies. "Chemists, assayers and metallurgists" were censused as 60,000 experienced and 57,000 employed.

or more of newer, more specialized engineering societies may make our index of engineers too gentle in slope during the present century, although one survey of the total engineers in the country found them to have the same rate of increase as our members of the five basic societies.[82] Blank and Stigler find the rise of censused engineers to have been 4% higher than our ratio, and the censused chemists twice as high, to 1950.[77] Comparison of our data on potential inventors with various governmental counts[84] of employment in science and technology (reaching back to 1870), scientists, Ph. D's under 70 years of age, etc., shows full conformity with our slopes, and with each other, except that the engineers increased slowest, and the Ph. D's fastest.

[63] It would be desirable to know whether the proportion of engineers and scientists engaged in invention or research has remained the same. There are various recent data,[85] as that in 1954 among the scientists and engineers employed by private industry, the proportions in R&D were of the engineers 25.7%, chemists 44.6%, metallurgists 30.6%, and physicists 63.4%.[85] In the four years ensuing the percentage of all engineers and scientists to be engaged in R&D rose from 27 to 33%[86]; and by 1959 those primarily in R&D in industry had come to be 36%,[87] 277,100, helped by 56% as many technicians, who were 28% of their craft. For a longer view and perhaps greater significance we may resort to our chart 4. It shows that the ratio of the professionals in organized research, to the number in the major societies, as reckoned in the graph superweighting the physicists and chemists, (¶ 74) rose from 17% to 52% between 1920 and 1941, then fell to 31% in 1946 and closed at 57%. Or taking the unweighted count, mostly engineers, the number in R&D rose from 28% to 89%, then declined to 46% and closed at 94%. Any accuracy as to the percentage of their time given to invention by the pertinent professions seems unattainable; but this need hardly disturb us. For those scientists and technologists probably had much to do with invention in the decades before they joined the laboratories, in business firms, or even if they were working only in pure science, or designing engineering structures, or educating future inventors. Our index of society members is only 1 of 4 subtotals, is given a weight of one-fifth among the inputs since 1924, and its graph is quite parallel to the rest, both before and after the start of laboratory statistics in 1920.

[64] Still there is here, in the apparently rising proportion of the scientists and engineers to be found in the laboratories, a consideration that should lead to steeper slopes than we have drawn, just as would also the rising ratio of assistants helping them (¶ 58).

[65] All our indices of input are based on the general idea that invention has become a business, an industry like others, whose marginal output may be expected to have a regular even if not unchanging, relation to its marginal input and its publications. We repudiate the old idea, not so remote from the truth in former and ancient times as now, that invention is an unforeseeable series of lucky accidents, springing from the inscrutable genius of a few individuals. But we admit in later pages various weaknesses in our theory, and probably a considerably greater rise in inputs than in output of invention.

[66] Our 14 charted *indicia* on invention yield strikingly parallel graphs, steeply rising throughout the years each covers, except for the few electrical engineering abstracts, and for minor irregularities,

some explained later, including the recent military restriction on publication. Our dates of counting leave out most of the strictly war years. In general all the indices powerfully confirm each other's significance.

[67] Next, for comparative and general purposes, but not for construction of any index of invention, we have plotted on chart 1 the courses of population in the U.S., and of U.S. patents granted to American residents,[27] (chemical patents to all are on chart 2 [89]), and productivity [44] per man-hour, in Mining and in All Manufacturing. Productivity, as we said (¶ 51) reflects the cumulative effect of all pertinent past inventions still used, and many other factors.

[68] Now to combine on chart 4 our various indices, to obtain subtotals by class, and indices of input and output. By the averaging principle each successive average should have more valid significance than its constituents singly. But first any average, or any index, implies a system of *weighting*, even if the constituents be assigned equal weights. Weighting must be done by a judicious preferential combination among the four principles which must guide it, viz:

[69] 1. The principle of Simplicity, which calls for saving the time of the scientist and his readers, and also avoiding the appearance of perversion of the results by manipulation of the weights (although more or less of manipulation is also indispensable for securing truth).

[70] 2. The principle of Potency, which calls for giving more weight to those factors more influential at producing the result inquired into. Thus we should give more weight to Engineering in the early days, and to Chemistry as times goes on.

[71] 3. The principle of Typicality, or Representativeness. Anticipating our findings, we may conclude that one index, say the total research professional staff, should be a better index of inventive effort than the others are.

[72] 4. The principle of Diversity of Approach. If two or more indices reflect more or less the same factors, we should weight each less, to reduce duplication, and to favor the quite different approaches. It is a principle of science that when a new or uncertain concept can be come at by quite different evidence, like the various ways of figuring the age of the earth, or divining what minerals may lie below a certain location, by the many diverse methods of geology and geophysical prospecting, then if we discover some agreement between the findings by our various approaches, we are much reassured.

[73] Applying these four principles, therefore, first to obtain the subtotals of chart 4, and taking first of all the Abstracts, our measures of Inventive Output, it seems well to weight all these papers equally,[90] which will automatically give preponderance at first to Engineering, but as time goes on will increasingly weight Physics and Chemistry. The abrupt check which the publications suffered at 1940 would naturally be caused by the large entry of military secrecy; so we have continued by a dotted line to 1960 the remarkably straight slope which this graph had followed since 1920 (¶ 83).

[74] As for the memberships in the professional societies, we should according to principle 4 [91] load the weighting of the chemists

[91] We also recall under principle 2 of Potency, that larger percentages of the Physicists and then of the Chemists are engaged in industrial R&D, than of Enigneers, as per ¶ 61.

and still more the physicists, lest the engineers swamp our index, though they should indeed predominate in the early decades, according to the history of invention in America. Accordingly, we assign weights of 1 to an engineer, 3 to a chemist and 6 to a physicist. The original percentages according to our data, with the assigned weights and resultant proportions, may be read off from table 4,[92] below, for each of the 3 professions, at 4 different periods.

[75] Among the students preparing for the three professions, engineering students naturally vastly outnumber the Ph. D.'s in Chemistry and Physics, and are far less significant per capita for invention, since they include many who went to college but a year or two, and who never made an invention, joined a professional society, nor realized any ambition but to operate machines or instruments. So for each one of them we weight the Doctors 150 in Chemistry and 187 in Physics, and thus preserve some influence in our combined index, for these sciences whose discoveries, particularly physical, are so pervasively potent for enabling further invention (principle 2). We have also lagged these educational data, in chart 4 though not in the earlier charts, so as to apply them to the later period when those students would have become most active in invention and discovery—15 years later for engineering students and 11 years for the Doctors.[93] The resultant subtotal lines of chart 4 are more strikingly straight and parallel than before.

[76] Next we apply the same general principles of weighted averaging to obtain our index of Input, or Inventive Effort (chart 4). To the measures of technical schooling (lagged), and of society membership, which somewhat duplicate each other, we give a weight of 1 each. From 1920 on we have what should be the best single index on inventive effort, the total Professional Staff employed on organized R&D. So we give this a weight of 3, making it a three-fifths factor in the totals from 1925 on. To connect it up with the prior data we in effect, for the averaging purpose only, slide it up the page just enough so that its 1920 foot settles at the average of the others. This

[92] See the following table:

TABLE 4.—*Original proportions and weighting for Chart 4*

[For preparing the subtotals, of society members, and of technical schooling lagged. 4 sample years.]

Year	Engineering			Chemistry			Physics		
	Percent found	Weight	Resulting percent	Percent found	Weight	Resulting percent	Percent found	Weight	Resulting percent
1880	Society members, 84.6	1	64.7	15.4	3	35.3			
1910	Society members, 77.2	1	50.8	20.6	3	40.6	2.2	6	8.6
	Technical schooling, 99.6	1	60.2	.3	150	26.7	.1	187	13.0
1920	Society members, 72.8	1	46.5	24.8	3	45.3	2.4	6	8.2
	Technical schooling, 99.7	1	57.4	.3	150	25.8	.06	187	16.7
1955	Society members, 64.8	1	34.0	30.3	3	50.2	4.8	6	15.8
	Technical schooling, 99.4	1	50.4	.44	150	33.8	.17	187	15.8

[93] A survey of the Am. Chem. Soc. reported the average age at entry into the profession as 23, and the median age of members as 36. The chemical doctors in *Am Men of Sci.* got their degree at 25 (mean av.), the writer finds. 36—25=11. *Chem. & Engg. N.* 34:1731–81, 1956.

Link Relative method was similarly used to connect the pre-1898 data, which lacked the Technical Schooling that had nevertheless been a real factor. Lastly we combine our three weighted subtotals into one Index of Inventive Effort or Input, by taking their geometric mean.[94]

[77] Our system of weighting has been explained at length more to answer suspicion than because it is important. If the various indices to be combined into an average had all the same, parallel slopes and fluctuations, it would make no difference at all what system of weighting were used. Our constituent indices have strikingly parallel long-run slopes, as is evident from a glance at the charts, wherefore what weighting system we use matters little. The extent of error it might introduce doubtless falls well within the percent of general uncertainty in our whole program for measuring inventions, which we discuss further, and in ¶ 9–12.

[78] The values which can be read from the margins of chart 4 have no simple significance, save for the Abstracts[90] and the Organized Research Professional Staff.[62] All are for comparing a graph with itself and with other rates of growth, but the two named are also simple measures, with the decimal point supplied by the cited Notes.

[78.5] The indices of Inventive Effort and Output form very straight, regular, reliable looking graphs, particularly the former one, which is based on more numerous, varied, and better kinds of evidence. The Abstracts suffered a sudden and permanent setback in 1940–5, which would seem due to secrecy entering as a major factor from then on. Accordingly, we have continued by a dotted line the straight course of the abstracts after 1920, and shall use this assumption in our further calculations.

[79] Our graphs are steep, increasing to 105-fold for the corrected Abstracts Output and to 345-fold for the Inputs. Those are rises of 79% per decade and 6% per year for the Output, and 107.7% in each decade for the Inputs, more than doubling, which means 7.5% per year. In the same period patents to Americans have increased only to 3-fold (chart 1). If inventive output be truly measured by the Abstracts, that would entail that the proportion of inventions patented, or more accurately, the ratio of patents to invention, has gone down to 2.9% of what is was only 75 years before, in 1885.[95] These conclusions are so surprising, and would entail such a changed view of the present and future of the patent system, that we should next ask whether such a statistical conclusion can be believed, and

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[94] The geometric mean was chosen as the most suitable kind of average for this case, because it is affected equally by the proportional fluctuations in each of its constituents, regardless of their absolute magnitude. Thus, if one constituent index fell from 4 to 2, while another was rising from 500 to 1,000, the two movements would just cancel out by the geometric mean, whereas by the ordinary, arithmetic average, the result would have reflected almost exclusively the latter index—½ (504→1002). The geometric mean is obtained by multiplying all the items together, and then extracting the corresponding root—if 3 items, then the cube root of their product. Weighting is introduced by multiplying an item by itself. Thus, from 1895 to 1925 we had two items with equal weighting to multiply together and extract the square root. Thereafter we multiply that product of the two, by the cube of Professional Staff, and extract the 5th root, all easily done on a slide rule. The geometric mean is a standard average in Statistics for suitable cases, used, e.g., in computing the Government's index of prices.

While our graph of Inputs embodies the same cited weights throughout the period of each subtotal constituent (each constituent one type of evidence, in all the three sciences), these had already included weighting, greatly altering, according to the respective rises of Chemistry and Physics and the relative decline of Engineering.

[95] During 1880–85 patents approximately kept pace with Abstracts.

just what it is that we have measured and found increasing something like 105-fold (Output, Abstracts) or to 345-fold for Inputs.

Can the Growth of Inventing Have Been so Great?

[80] The complex we have measured has been chiefly Inventive Effort, or Inputs; only the Abstracts have represented Output, successful invention and discovery. So we should now ask what is the quantity relation here of input to output. There is no reason to suppose that a unit of effort would in all decades produce an unchanging number of units of invention and discovery. Machlup [96] and especially Sanders [97] have discussed this extensively from the theoretical point of view, with hypothetical calculations indicating that the availability of capable inventors, and the amount of invention obtainable per dollar expended, is likely to fall off greatly, with much of the money spent going as a "rent" in the shape of bid-up pay to inventors so employed, and most of the rest going to engage new men of inferior talent, interest in invention, and/or training for it. This theory is supported by the fact that the labor of 100 professionals in the laboratories was pieced out by 35 subprofessional-grade workers in 1921, which supplement rose to 180 per 100 in 1953–4. R&D has come to occupy 32% of industry's scientists and engineers, 90% of them full time, and 27% of its 594,000 technicians in industry, or 53 per 100 of the higher rank.[63] Technicians of course are only part of the sub- and extra-professional workers for invention. Professional men and students will be drawn into the inventive field from the life sciences, teaching, and all the professions, as Machlup demonstrates.[177]

[81] Another principle of diminishing returns might also operate, that most of the easy pickings, the mechanical inventions that any ingenious talent might think up—have by now been mostly picked up, so that chiefly hard ones are left to struggle for. Again, some think the modern regimentation in laboratories, with their assigned tasks, is irksome and sterilizing to inventive genius, and that the laboratory hires many a time-waster. Possibly so; but if the laboratory system is on the whole less productive than the old, less organized invention system of the 1880's, why do the corporations and government not discover this, and stop wasting 13 billion good 1961 dollars a year on the laboratories, and stop increasing their R&D real budget at a phenomenal 2½-fold per decade? Certainly it is the author's own experience that he accomplishes more under an intelligent and suitably aloof paymaster than when left entirely to his own devices. We shall charge later (¶ 622–41) that the collegiate training and traditional life scheduling of our engineers has a stultifying effect upon inventive talent, but never deny that technological training nevertheless becomes ever more necessary for invention. Sanders finds engineers today contributing 90 times their per capita share of patents, and Schmookler that 64% of patents are signed by technologists, plus 17% by executives who might also be such; [99] and Carr, although arguing in favor of the lone inventor, found similarly.[100]

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[99] Correlating the pat. scores of the Amer. States with their respective censused numbers of graduate engineers, chemists, assayers, and metallurgists, Schmookler gets an r^2 (coefficient of determination) that indicates hardly any relation (0.08) between the 2 variables in 1900, but which has risen steadily to 0.83 by 1950, indicating a very strong, almost inseparable causal connection. Adding to those technologists other, less pertinent classes, of civil engineers, architects, designers-draftsmen-and-inventors, and surveyors, reduced the rise to only 0.37→0.76

[82] While those factors for a diminishing yield of inventive effort may all be valid, there are the countervailing forces. Appropriate education, not only in engineering, but in physics and chemistry (whose doctors are shown to have vastly grown), must certainly facilitate invention. And so do the documentation of past work and appropriate new science (reflected in the Abstracts), and all the proliferation of equipment and specialized services which the modern laboratory puts at an inventor's disposal. If he find he needs some cold near absolute 0, or an electron microscope, or a mathematician, or a translator of Russian, they are right at hand for him. If the contribution of these assistants, who increased during 1921–54 from 35 to 180 per 100 professional scientists and inventors, had been included, our graph would have been still steeper.

[83] It seems probably significant that the Abstracts, our only measure of inventive *output*, the rest being measures of input, have risen less steeply than the other criteria (following the dotted line of chart 4 and ¶ 78.5, 79). We found the outputs rising to 105-fold, while the inputs soared to 345-fold, as the somewhat differing slopes show. The very real difference recorded strongly suggests a declining yield from inventive effort.

[84] Further considerations on the meaning of the indexes will be taken up in ¶ 98. In fine, which way the ratio of inventive success to effort may have been changing, still remains somewhat a mystery. But it seems more likely to have declined, as indicated by the steeper slope of our Inputs graph on chart 4.

[85] But is a rise of 345-fold, or 105-fold, in the last 80 years, too much to believe of any large phenomenon? No. Our mere population more than trebled, and the measurable contingent of it which contributes practicably all the inventions, viz., the male whites aged 20–59, has grown to 3.62-fold, leaving 95- or 29-fold to account for ($345 \div 3.62 = 95$). One can find numerous other things that have risen comparably or faster. From 1880 until 1955 only, telephones multiplied 1,160-fold, cigarettes 754-fold, ice cream 4,150-fold, power 16-fold, productivity times workers (cf. chart 1) about 25-fold, secondary education 68-fold.[102] One might object that the greatest growths are in things that hardly existed in 1880—telephones, autos, cigarettes, aluminum—so that our ratios of rise are rather as if we had divided by 0, a procedure forbidden in mathematics. True; but the same swift growth of inventive effort continued through all the later years, not just in starting. Furthermore, invention of the modern, organized, scientific sort, and physical and chemical discovery, are also things that hardly existed in America in 1880. Edison had a small laboratory, and that was all; his good one at Orange was built in 1886, and du Pont's in 1889. Inventing there was in 1880, and patenting, each abundantly, but not through laboratories nor organization, and often not through science, but by the individual ingenuity and informal labors of mechanics, technical men, businessmen, a little handful of

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Other calculations by occupations, of the responding 87/122 inventor-patentees, indicated that 75% made the invention as part of their job, and that 67% were technologists and 15% executives, perhaps also technologists, 13% other. He concludes "During the [50-yr.] period invention changed from an activity overwhelmingly dominated by independent individuals to one less overwhelmingly dominated by business enterprise," more than three-fourths of the total, using captive inventors trained in the rising technic professions, whereas the earlier patentees had come from many walks of life. Cf. ¶ 396 ff. later. J. Schmookler: Inventors Past & Pres.: *Rev. of Ec. & Stat.* 39: 321–33, 1957.

professional inventors, and by men of all sorts. They turned out wonders for their age, and helped bring a vast economic growth. But however precious, their inventing and patenting was almost always a simple, amateurish, tossed off thing, compared to the thorough, elaborate, perfected, scientific product of thousands, even millions of man-hours of labor by highly trained scientists, engineers and their assistants, that constitutes the great and valuable bulk of the invention industry today.

[86] It is quite an industry, you know, today, with its own press, such as the journals *Industrial Laboratories* and *Research Management*, and a budget for all R&D of 14 billions of 1961 dollars, 2.78% of the Gross National Product. Since so little of all this existed in 1880, and it is what our indices chiefly measure, a growth to 345-fold is easily possible with this virtual creation of a new industry, that of scientific invention. Kreps said that the invention of invention, as A. N. Whitehead called it, and the coming of science, make invention an inevitable product of scientific advance. Competition encourages carrying it possibly even beyond the proper economic limit, through optimism, pride in one's product, fear of being outstripped, and tax benefits.[103]

[87] Similar rates of growth characterize other countries' R&D, Dedijer shows.[662] The American percentage of the GNP is nearly matched by Britain and Russia, and in descending order by Sweden (1.8%), West Germany, France and Canada, while the smaller and the poorer countries usually find it easier to copy than create. Price [663] also presents convincing measurements of the growth of the world's science, through counting scientists, scientific journals, abstracting journals, discoveries, and R&D funds. Cf. also ¶ 54.

[88] We have always thought that much of the growth registered in our indices has been in organization, science, and literacy, rather than in inventing proper,[104] so that our growth measure would be exaggerated if taken for invention alone. The modern invention industry reaches backward into science, making the discoveries needed, and sometimes reaches forward into designing, perfecting, and marketing; and much of this figures in our indices, unavoidably. Those aspects are all necessary for invention; but probably they were not so much represented in our indices for the early years. These wider reaches have never been patentable. Kottke [105] points out the difficulty of separating research and invention from designing and innovational engineering. Since it is a modern fashion in industry, and possibly in government, to boast of the amount spent on research and development, it is likely that many expenses and personnel which do not belong under our concept of invention plus invention-oriented research have got into our statistics, inflating their rise with this

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[104] While we distrust definitions in social science, it will be evident that our working definition of invention is a broad one, including all manner of new practical ideas, big and little, that are useful to produce goods or services, up to the boundary of Science, and far wider than the scope of patentability, to which technical people are apt to restrict the word's use. (¶ 111, 576.)

[105] "In compiling its directories of industrial laboratories the Nat. Research Council has attempted to segregate research from innovational engineering. These directories contain ample evidence that businessmen are not agreed where the distinction is to be drawn, accordingly. The dissociation of industrial research from innovational engineering is in the main historical rather than functional. One cannot understand the relation of business concerns to technology if he has eyes only for the work of men who hold advanced academic degrees." Kottke, N 211.

further business of progress, in some of our steepest historigrams. Also much invention work has in the last generation or so come to be organized and counted in R&D departments, that was formerly performed by executives and members of the production staff, without separate accounting.

[89] All our indices except those for engineering include a considerable element of scientific discovery in physics and chemistry, and not just invention. Such discoveries inevitably lead to invention, but not at once nor necessarily in the same country. Physical science discovery, which has never been patentable, was a realm in which America had little share in 1880, but an increasing part since, as reflected in the rising share of American papers in the chemical [67] and physical abstracts,[68] as per our citational notes. What original science America produced in our early age was wisely confined mostly to the descriptive sciences and medicine, not those forming the direct base for invention. For novel physical and chemical discoveries on which to contrive inventions we depended chiefly on Europe then;[107] but today the exchange is nearer even. We may see that our output in physics and chemistry rose from almost nothing in 1880, to 30 and 20% of the world's indexed publication in 1961, and higher somewhat earlier. We have given before (¶ 54) some measure of the relative rise of America in general invention and discovery.

[90] Surveying our graphs for clues, we observe first that all the indices of Chemistry, both pure and applied, are strongly climbing. This science is well known to be in the ascendant, so we may leave it for some observations a little later (¶ 105). Physical abstracts have a milder slope, and engineering abstracts and the few in electrical engineering lag yet more. The indices of modern laboratory expenditures in stable dollars are the steepest of all. We may perhaps see a pattern in all this activity, for modern work outside chemistry, to wit that the indices showing the *least* rise are those which especially reflect invention rather than science, or science rather than invention, while those evincing the abruptest modern upsurge are those joining both science and invention. One might say again that invention is old and science is old, but scientific inventing *in laboratories* by scientific men is a new thing on the face of the earth, and hence capable of multiplying itself 345-fold and more yet. But this is not just patentable inventing, nor invention without qualification, which we should most like to measure and compare with the patenting score; but our scientific inventing has become most of it, partly because it includes most of chemical activity. Schmookler's statistics indicate that about three-fourths of currently patented inventions come from scientifically trained men, with a great rise since 1900, and the same proportion from men who have invention as part of their business. (See ftN *99*, p. 31.)

[91] All the criteria of our indices represent best the top level, most literate and scientific fields of invention and physico-chemical research; and these would naturally have been expanding faster than the humbler levels of old-fashioned inventing, say of gadgets by ingenious technicians. The upper level is certainly the more important one for today and the future, but not so much more important in the 1880's. Taking an extreme example from farther back, in 1813–41 the whole navigation of the Mississippi valley was largely created by the inventions of a great hero of American history, Henry M. Shreve,

whose name is practically forgotten today, because, although a genius at invention and technic organization, he was not a learned nor political sort of man, took but one patent apparently [108] and published nothing. But today inventions of such importance would be reflected in hundreds of articles (and indeed there were many published notices of western steamboats, etc.). To a considerable extent, as we have said, our data reflect the advance of invention in scientific character, organization and expression in print, rather than the advance of invention *per se*. That the counts of scientific and technic articles, which should reflect this most strongly, present the gentlest slopes, is explainable by military secrecy of late, and by a probably falling ratio of inventive success to effort (¶ 83). The laboratory staffs, which might come nearest to measuring invention proper, parallel our general average, but leave out the laboratories' growing supplement of subprofessional personnel (¶ 58).

[92] Five of our six Abstract series show an especially swift rise at the start, probably reflecting enlarging coverage and possibly explaining the upward bulge of 1895–1920 in the combined Abstracts count (chart 4).

[93] To measure or evaluate the lower-level inventing would be obviously desirable, but difficult (save as it is included incidentally) just because it is less published, and its authors often obscure men. Still a vast amount of lower and lowest level invention *is* reflected in our indices, because it is an inescapable preoccupation of all laboratories, article writers, and inventors—scientific or not—to perfect their work in every detail.

[94] One of the lowest types of invention has been lately statisticized, in the inventions and other suggestions accepted by employees' suggestion systems, on which there is considerable recent accounting.[109] Data from 235 companies and Government offices, with 6.4 million employees, reported 1,686,265 suggestions from 319,084 employees, of which 435,774 suggestions were accepted, 26%, and rewarded with an average of $33.49, the highest one receiving only $12,475. Scarcely any of the accepted suggestions were patented, say 1 in 1,000.[110] The estimated savings in the first year of use were $20 million.[111] While a large part of the accepted suggestions are not inventions, we still see here a flood of lowest-order invention, which is neither rewarded with nor motivated by patents, and which has little direct connection with publication nor with any of our indices (¶ 57).

[95] Having confessed that our graphs on the progress of invention and research, above all the organized and scientific type, have not so much to do with with the lowest grade of invention, which is still important today and was relatively more so in past generations, we shall next observe that *patents* likewise have been growing more scientific, chemical often, lengthy, and their inventions oftener utilized (¶ 116), though modern patents are not so successful in court. Patents too, as we just said, have little to do with low grade invention today. Their improving quality, enforced by courts and Patent Office, is one explanation for the precipitous decline in their count, relative to swift rising invention. So there is not so much unfairness when our statistics compare especially the modern, scientific type of inventing, with the modern, increasingly scientific sort of inventions that are patented today. But although patents have risen in scientific quality, they may

not have risen so much as the largely scientific *ensemble* reflected in our indices. Dr. R. E. Wilson suggests that perhaps modern inventing looks so far ahead that a 17-year patent is less attractive than formerly.[112]

[96] It may be that the generally steep rises we have recorded reflect further large social factors—the great efflorescence of higher education, which should help inventors, the larger scale of businesses, often reaching monopoly or oligopoly; more tendencies and means to communicate; permitting, and even encouraging employees to publish articles; and as to patenting, a more social rather than competitive outlook. But such trends, especially toward more education in science, might be expected to foster invention. And comparison of the various indices does not bear out this theory. Still it seems quite possible that our indices would not climb quite so high if they did not reflect so much of science, and possibly other social trends, and not just invention proper.

[97] Yet there can be no doubt that science, especially Physics, Chemistry, and Metallurgy, is a basis for further inventions . And we must not forget two other important considerations that would make our graphs steeper than drawn, viz., the increasing percentage of our physicists, chemists, and engineers who are employed in the laboratories rather than in less inventive occupations (¶ 63, 64) and their being helped by a fast growing supplement of subprofessional-grade assistants (¶ 58).

[98] The possibility of a vertiginous rise in invention, such as the 105- or 345-fold indicated (reduced to 29- or 100-fold by the pertinent population growth) is explainable partly by the mathematical theory of combinations and permutations. The more elements of technology and science are known, the more of different new combinations and permutations can be made from them, in steeply stepped up ratio. This does not oblige invention, but invites it. On the other hand, the multifarious proliferation of data and past work to be considered, with the growing requirement of scientific training to master it, tend to make inventing harder (¶ 80–84), as economists have pointed out,[112] although this tendency is countered by developments in documentation (bibliography), team research, and longer education. More population and still more inventors in the world would also increase *duplication* of work (countered by communication). Cf. also ¶ 81, 82.

[99] Wilson [112] thinks that basic science, for all its rise, has probably, through insufficient cultivation, failed to advance as rapidly as its applicability invites, hence retarding technic progress, below the still vertiginous upsurge that we observe in both science and invention.

[100] The average invention might become more scientific and yet less valuable, and less impressive. The great economic principle of diminishing returns would suggest that as we have come to spend (as demonstrated) vastly more dollars on invention, the marginal dollar spent would bring a product of declining utility, even if the efficiency of the inventors did not fall off as per ¶ 80 when far more men are drawn into the profession. The year 1867 gave us the telephone; [115]

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[115] By Danl. Drawbaugh, according to a whole village-full of witnesses, whose unanimous testimony the Supreme Court nonetheless brushed aside (by 4 to 3), because D. was an obscure tinkerer and had been slow to assert his claim. The 1876 telephone claims of A. G. Bell, simultaneously rivaled also by Elisha Gray, present apparently an extraordinary history, both of duplicate inventing and most successful patent chicanery; told, with citation of court cases and Government claims, by Petro, ftN 9, pp. 354–71. Cf. also ¶ 285 & ftN 291.

1963 gives us minute improvements in telephony, hundreds- or thousands-fold more numerous and inventor-consuming, and likely more valuable as a whole, but worth much less per invention, and not impressing us, unless we take the statistical view of things, that view which enables us to feel the combined weight of a vast number of trifles. In one's unmathematical, common sense view of history all decades seem equally inventive, as we found anent the attempts to measure the progress of invention by counting the "great inventions" of each decade (¶ 52, 53).

[101] Two minor defects may be found in our statistical procedure. The indices for the earlier years are (unavoidably) rather few, only three for 1880 and four for 1885. Secondly, in the counts of abstracts only, other than chemical, the author being obliged to do his own counting, chose volumes at intervals of 5–10 years, and avoided the periods of war and the Great Depression. This should not affect the general slopes, nor the maximum heights arrived at, but it presents a slightly false picture in not showing all the slumps that probably occurred in depressions and wars. We see such in the yearly or biennial data available for the other indices, although the slumps did not occur in all cases.[117] The end result is a small overstatement of the amount of invention and research accomplished, though not, it would seem, of the overall rates of progress, our main concern.

[102] For all our argument and displayed evidence in the graphs, some readers are probably still gritting their teeth and saying: It just can't be true that American invention has increased anything like 105-fold in the last 80 years! For there is the evidence (forsooth!) of patents, and of the lists of great inventions, which show no advance even for population growth, and there is our general impression that some advance has occurred, but no vast change in the invention situation.

[103] How can we answer this obstinate feeling that our new statistics must be wrong and the patent and great-invention statistics about right? Only by recalling our previous arguments. First the population factor, whereby the increase of invention may have been only 29-fold per pertinent capita (¶ 85). Next recall (¶ 53) that the usual, almost inevitable impression of recent history, i.e., the informal and unstatistical (and therefore unscientific) impression, is that each generation had its outstanding achievements, great in comparison with their minor and obscure coeval ones, and therefore seeming great in an absolute sense; so the leading achievements of one generation look as numerous and great as those of another. But this conclusion is completely unwarranted by logic, and by the statistical evidence like our graphs which are *not* dependent on a changeable vogue of patenting, nor on the subjective impressions of off-hand thinkers appraising the inventions of recent decades. If the periods had been all distant, say of the Middle Ages, we could compare them with more objectivity, but still not with much, and far less than with our statistics based on con-

[117] The discrepancy between this minority of our graphs and what were desirable, is the difference, e.g., between an index of the progress of steelmaking capacity, and an index of steel production. The peaks and general slopes of the two graphs would be the same, but the graph of production would show various slumps caused by strikes and depressions. Many of our graphs are essentially measures of *capacity* to produce inventions and discoveries; but sometimes the actual production fell below capacity for a year or several, due to depression or war. But invention is not greatly checked by depression, and is stimulated in certain fields by modern war.

temporary counts and expert judgments of millions of items. Modern invention can only be apprehended and sized up by statistics, because it is mostly outside the experience and possibility of comprehension by any of us. Even if we are a technologist, a physicist, or a chemist, we are not all three, and further acquainted with the latest skirmishing on every far-flung frontier of invention today and for each past decade since 1880. Take a minor improvement in electronic computers—we have not heard about it, only a handful of technologists ever will, and we could not understand it, but it is an invention, one of millions being made, and it could be patented, if patenting were still in favor. *Our only way* to know and truly evaluate such inventions, is by statistics. We must trust statistical science. By the alternative, which is to trust common sense and experience, a microbe, an electron, and a galaxy are impossible—nothing is, nothing *could* be so small or so big as the scientists say those are. Indeed, even a billion of dollars or people is impossible, because we can't imagine that big a number. If we are to be scientific we must accept the commands of science—measure whatever you can, and when you have found reasoning that is inescapable, go with it no matter whither.

Other Considerations, and Conclusions on the Charts

[104] A large consideration, affecting all our indices, especially the abstracts, but also the patent count, is that a very large part of modern scientific development is for *military* purposes (as may be verified from the Funds on chart 3), and is therefore hampered in both publication and patenting. We see a probable reflection of this in that our graphs of physical, electric, and engineering abstracts—areas closely identified with military research—are slower rising, or even falling, while the chemical rise as steeply as any index.

[104.5] A matter of great social importance, which Solo has developed,[670] is that as most of our physical scientists and inventive men and facilities come to be assigned to military, space, and atomic tasks, they are drawn away from such undertakings as upbuild industry (as well as taking patents), thus accounting for the often lamented check to our economic progress. To be sure, there is a "spillover" from these arts to the civilian ones (¶ 7), but this takes years of time, as shown by the small number of patents taken for commercial purposes, when allowed on government work (¶ 521). The lag has lengthened especially since war has changed from chiefly a handling of great masses of men and familiar materials, much as in civil tasks, to the strange, exotic fields of atomic energy and space navigation. This would account for the lack of any visible correspondence between Solo's graphs of R&D, and increase of general productivity. Using a special price deflator (N 58) he figures for 1953–60 a probable slight decrease in effective R&D bought for civil industries, which upbuild the economy, while in the same years the space-military acquisitions of invention rose to 2.33-fold. If the international situation does not permit reduction of our space-military inventive effort, Solo shows means by which the spillover into civil technology can be fostered: less secrecy, more documentation, the universities' work of generalizing diversity and teaching new science, and the education of businessmen as well as scientists for this transmission. Something

is being done in these lines by NASA and AEC, and more is sought through the new Panel on Civilian Technology (¶ 436) and the new Civilian Industrial Technology Program (¶ 567.5). Solo counts medical research as not upbuilding the national economy; but most of it does, through increasing the health and number of workers living.

[105] We have paid special attention to *chemical* invention and patenting, as on chart 2, for various reasons. A good chemist's work is mostly invention, or scientific discovery which soon leads to it. Chemistry has become a great field for patents, contributing 26% of them in [89] 1945 and 31% now, says Dirlam. "It is clear that the patent system has come pretty much, as far as its commercial usefulness is concerned, to be the preserve of the chemical and electrical industries." [119] Yet chemistry is also the most suitable field for secret processes, and secret infringement. But there is said to be remarkably little patent infringement in the industry,[120] due to intercompany comity, patent pooling, and a policy of competition by finding better chemicals rather than by invading another firm's line. Another influence for less strife and probably less patenting must be the admirable internationally standardized nomenclature for chemicals, enabling ready indexing and hence the discovery of anticipation before patenting. From this clarity of name chemical patents are being worked up for the first trial of modern electric search methods to be applied to patents.[121]

[106] The growth of the pertinent population (¶ 85) to 3.62-fold since 1880, which explained at least a corresponding share of the rise of invention, affects patents and all the indices equally, so has been usually ignored. Of all our historigrams, only those of Productivity do not contain this factor.

[107] A disquieting development since around 1950 is an almost complete check to the rise of chemical and physical doctorates and engineering students. To be sure there has been a sharp rise in engineering doctorates, to 1,009 in 1961 [122] (chart 3; not combined in the indices); but this by no means meets the needs.

[108] The graphs are as straight and parallel as one could ever expect from the imperfections of the data and the severity of the military and economic crises traversed. The bulge in the Abstracts, during 1895–1920, has a probable explanation (¶ 92). We may also observe a slight bending, a check in the rate of growth, occurring in each constituent subtotal sometime between 1900 and 1920, and in most of the basic graphs and in patents. If we divide our overall index of inputs at the year 1905, in the earlier period it rose at a rate of 2.28-folding per decade, and in the latter period at 1.98-fold per decade. What caused this check we can only guess, and not usefully.

[109] In fine, our summary indices of Inventive Inputs and Output (chart 4) seem fairly justified, entail a rapid fall in the proportion of inventions that are patented, and seem to stand well enough all the tests of internal consistency, logical basis, and statistical reasoning, except that their Probable Error is considerable. Our graphs may well climb too high, especially because they probably include a large and growing element of chemistry and physics apart from invention, and probably underrepresent the old-fashioned, unscientific, little organized or published inventing, which would be a larger proportion

the farther we go back. But on the other hand, there is in recent decades much invention unpublished (and unpatented), because military, and the scientists and engineers are giving more of their time to invention than we have taken account of, and have more of subprofessional helpers. All in all, our indices seem significant and reliable within a wide probable error, and present a striking contrast with the downward course of patenting. The precipitous decline in proportion of inventions patented should never be forgotten in any discussion of the patent system and its substitutes. But we must not think that the patent *system* has declined so fast as the count of patents, since we have mentioned that the modern patents are of better quality and wider scope than the earlier ones (¶ 116).

[110] The shrinkage in this proportion would probably be still more marked if from our graph of patents to Americans (chart 1) we eliminated those that are not truly part of the patent system, as will be explained a little later (¶ 128). For such little-functioning patents, to the Government, universities etc., have probably formed a growing share of the granted patents, since 1880.

[111] One further reflection, between our preceding attempts to measure and verify the great decline in the patent/invention ratio, and our following attempt to *explain* it. Likely our difficulty in measuring invention across modern time, which no one before has seriously attempted, except by much briefer treatment of similar data, is due to the fact that neither this writer nor anyone else knows just what is meant by "invention." To measure a thing, whether by counting or otherwise, we must first delimit and define the thing to be measured or counted. Walker in his treatise on patents gave 45 pages to defining the word "invent," while the Supreme Court has said it cannot be defined.[123] Perhaps from being a sociologist, the author would say that the only definition of the word is the social or lexicographer's one of commonest respected usage. In short we are trying to measure we can't say just what.

[112] Nevertheless there is *something* very real and that we all understand alike today about that word *invent*; Machlup agrees.[124] As in our previous partial definition (ft. N *104*, p. 33), it is something that always embodies physics and/or chemistry, and practical utility, and that is the very opposite of resting content with old technology, and that has changed and grown enormously with time. Modern man makes more inventions each day than Neanderthal man made in 100,000 years. We can be sure of that, we can prove it by statistics, such statistics as we have been compiling, from reliable, sufficiently objective sources, embracing millions of cases. The various bases of our statistics—the nature of a doctoral degree, an abstracted article, a counted engineer, a stabilized dollars' worth of research—have been sufficiently constant in their respective definitions, since 1880 or the later date when each index started, so that their properly averaged result must be significant, and indicates a rise of inventing if not 105-fold, at least somewhere in that neighborhood. Since patents to Americans have risen only to 3.1-fold, it stands proved that the ratio of patents to American invention have fallen far, even if we cannot say just how much.[125]

[113] After all, we are not trying to measure invention absolutely, to say how much of it was produced in a certain year, but only how one year's production compared with another's.

Why So Much Less of Invention Is Now Patented

[114] We set down at the conclusion of our patent history, some reasons why the patent system has held up as well as it has, enjoying an absolute importance likely as great as ever (¶ 36). Now to examine why it has nonetheless *relatively* fallen away in such a swift and accelerating decline in the last two generations to a few percent of its 1880 proportion to invention. One cause would certainly be the judicial disfavor demonstrated (table 2); but this in turn must have had causes.[126] One might well be finding more patents on old stuff, due to the increasing difficulty to harried examiners to search in few hours (¶ 295) through the ever vaster world of present and past published technology, while their unexamined applications pile up. However, this would have a first effect of multiplying patents. Numerous recent antitrust judgments, requiring licensing or even cancellation of great blocks of patents, as in the Hartford-Empire bottle, GE, RCA, Bell, and United Shoe Machinery verdicts, must have been an influence against taking further patents. One study shows a decline of at least 20%,[127] and much more in the companies hardest hit. "It has been the policy of the Bell System Co. since 1949 to license anyone for any purpose." [128] So the telecommunications and broadcasting companies, recently hard hit by the courts, had pending applications in 1953 amounting only to 2% of their patents in nominal force, versus 29% for all other companies.[129] Although Government business would be one explanation of this great and sudden check to their patenting, the fall in judicial favor would presumably be another.

[115] Another great cause of patents' relative decline is certainly the vast growth of inventing by or for the Government, which kind was near zero in 1880, but absorbs 61% of all organized inventive and pertinent scientific research today,[130] to which Solo would add 30% of that paid for by industry, but done to get Government contracts.[670]

[116] A part of the decline of patenting would be more numerical than important, due to the rising quality and significance of the average American patent.[131] Sanders [132] finds that today about 60% are put in production at one time or another,[133] and another 15% found of some benefit. But a study of 1951 or earlier estimated only 20–25% used. Still earlier authorities, such as Jewett,[134] merely guessing, doubted if 10% were used, and Vaughan [135] in 1925 that more than that ever paid for their fees, which Kaempffert [136] in 1912 and 1923 thought were paid by less than 5%; another 1912 claim was that only 1% of the patentees were financially successful.[137] Another suggestion of rising quality of inventions patented is in the percentage assigned to a corporation, reflecting chiefly or entirely the proliferation of corporations and of laboratories. Assignments on issue rose from about 12% in 1885, to be about 61% of patents currently issued to Americans,[138] ever since 1940. This will be increased to about 64% by later acquisitions. The 1938 figure on original issuance had been 51.7%,

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[131] Lutz says "The courts have raised the standard of invention to keep pace with progress in technology, and the Patent Office has followed this standard as it has progressed", so that it may be pointless to cite old patents. K. B. Lutz: Are the Courts Carrying Out Constitutional Public Policy on Patents?; *JPOS* 34: 766–91, 1952; p. 780.

[133] Of the patented inventions 40.2% are being worked currently, 17.8% have been in the past, and 1.4% are expected to be in the near future. Based on statements of the patentee and/or assignee. N 132. The currently worked include 53% of the mechanical patents, 40% of the electrical, and 33% of the chemical. N 165 & ftN *152*.

the 1922 percentage 27.4%, and 18% at the beginning of the century.[139] Assigned patents have always been considered superior to the unassigned.[140] If would be natural that as the proportion of inventions being patented declined, the ones omitted would be the least valid and significant. Another evidence of the progressively more serious and scientific character of patents may be found in their length, which extended 113% in 1907–53.[141] As inventors become trained chemists and engineers, they would waste less time inventing and patenting the chimeras of a "Goldberg"; and as industrialists, patent attorneys, and everybody became better educated, one would expect less folly and pretense to be patented. The patent bar has probably improved. Karl Fenning, former Assistant Commissioner of Patents and Assistant Attorney General, testified in 1935,[142] though doubtless with some exaggeration and anachronism, "Probably only one patent out of a hundred is taken by an inventor who has done anything more than answer an advertisement. You pick up the ordinary commercial journals and you will find men who are admitted to practice before the Patent Office advertising 'Can't you think of something to invent? Can't you think of some little thing? Take out a patent.' I am told that two-thirds of the patent applications filed in the U.S. Patent Office are filed by that group of attorneys. In general, that two-thirds of patents should be ruled out. They should not be considered at all."[7] The patent lawyer Rice adds, "Such patents are of course not a real part of the patent system; they are more accurately a Government-tolerated racket."

[117] Every uneconomic or bogus patent omitted is likely to be a minor social gain, and to mark no true decline in the patent system, but only in the count of patents. And with patents of real but small social value, their omission spells but minor decline of the patent system.

[118] An excellent test of the merit of a patented invention is whether it was also patented abroad. In 1925 Americans' patents abroad were only 12.4% of those taken at home,[51] while in 1950–54 Sanders calculates 55.3%, on a slightly different basis.[144] He also finds a rise of 11.4% in the number of inventors signing the average patent, between 1938 and 1952,[144] and an expanding proportion of assigned patents in which know-how was essential, from 44% to 57%, between the same years.[145]

[119] Patents in other countries seem to be likewise improving, while declining in proportion to invention. In Germany, Britain, Switzerland, Sweden, and the Netherlands there has been a strong and steady rise since 1900 in the proportion of patents kept alive, under the foreign system of progressively rising periodic renewal fees.[146]

[120] Still another cause for a relative shrinkage of the patent count with less decline in patent significance, might arise from wider coverage by the average patent. A corporation and any informed inventor, in deciding which inventions to patent, would certainly prefer those of wider possible application. Furthermore, a wider scope might proceed from improved science and understanding of the

[139] Jewkes, *et al.*, tell that corporate patents have similarly risen in England from 15% in 1913 to 68% in 1955. N 393, (his pp. 104–7).
[140] In ¶ 405 we take up and dismiss the contrary indication.

same. Better perception of basic principles enables writing a patent to have wider scope. Thus, in bygone times the rudder, close-hauled sailship, windvane, windmill, water turbine, propeller, and airplane wing and elevator were eight separate inventions, and very hard at that. But the modern engineer perceives that they all depend on the *vane* (or airfoil, hydrofoil) as their essential element for securing a sideward pressure from relative movement between the vane and a current. So when Flettner in 1923 had improved the Magnus-effect rotating cylinder by adding end disks, he applied for a single patent covering its substitution for the vane in all those eight inventions, for a rotorship, a rotor windmill, etc., and was granted it [147] with 55 claims, under American law which permits a patent to cover only one invention.

[121] A related consequence of more understanding science is an enlarging perception that other people's ideas in the prior art have, logically, wider ramifications than used to be perceived, so that they cover our own idea and should prevent its patenting, because modern technologists are so well grounded in perfected concepts and theory that they can and will perceive the applicability of the old principle to the different technic purpose, without need of our own perception and patenting. In these ways, therefore, the advance of science would tend strongly to make the lower grade patents less justified and less often granted, while not reducing invention, but only its difficulty. But by the same token, this more rational, scientific insight should lead to many other, novel and difficult inventions, which would merit and receive patents.

[122] The growth of corporate size,[148] which has been so marked since the 1880's, might tend to shrink or to expand patenting, more likely the latter. Growth lightens the burdens of inventing, and of patenting with its costly infringement suits. A laboratory of its own can hardly be afforded by a firm which can budget for it less than $120,000 a year [149] (though it can use the research institutes and other services). Manufacturing companies having 8 to 499 employees, though they contributed about 35% of the employment, put up only 10% of the R&D cost, whereas those employing 5,000 or more hired 40% and contributed 70% of the R&D.[150] The larger the firm the more use it can make of its suitable discoveries, whether patented, kept secret, or freely disclosed. Kettering said at the TNEC hearings when he was chief of GM's inventing: "So far as patents concern an organization like ours, I think they are only important from one standpoint." This is to prevent other people from patenting the same thing. But with other systems than patenting they could not. "I think patents still have an enormous value from the standpoint of the inspirational effect they have on people, and certainly for the small concern they are vital." [151] Indeed, the old-style, isolated inventor, whether a freelancer or a petty enterpriser, has hardly any other instrument to secure a good reward for his creativeness, save patents. [152] Cf. ¶ 73, 131.

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[148] Sanders finds, "that of the initially assigned patents, the larger companies obtain something like 65%; the smaller companies obtain about 35%. But of patents which were initially unassigned, but subsequently became assigned, over 88% became assigned to these smaller companies." The larger companies never worked 49% of their patents, but the smaller companies never worked only 24.5%, and those they worked they oftener worked intensively. Variations in Pat. Utilization by Different Types of Companies, *PTCJRE* 3 : 56–60, 110–4 ; pp. 57 & 111, 3 cited.

Little connection has been found between outlays for R&D, and number of patents taken. N 97.

[123] Monopoly likewise probably tends to reduce patenting; for the more a firm approaches industrial domination, the less it needs patents to give it monopoly over the inventions used. Jewett at the TNEC hearings said patents made no difference in the telephone company's work, but helped them get more ideas from outside.[153] So the growth of monopoly would probably be a factor in the decline of patenting, until around 1900. Since that date economic studies thought to be best [154] conclude that monopoly has not increased.

[124] However, patents have been found very handy to further a monopoly. And a wealthy corporation may patent a dozen rival means to do something where they intend to use only the best one (ftN *152*), but would like to have the rest tucked away, where they will not give a possible opening to competition, but rather form an imposing, apparently impenetrable barrier to competitors (¶ 169). Patent pooling and cross-licensing arrangements have become more common, as will appear later (¶ 478 ff.); and so has comity, friendly relations between companies, as in the chemical, petroleum, and auto industries. More gentlemanly and socially-minded executives are in charge; and all these factors, one would think, have probably weakened the urge to patent, to monopolize the invention for oneself. Standardization of goods, better education generally (countered by probable decline in native intelligence), higher ethical standards in the patent bar, and other likely reasons for less patenting, have been discussed elsewhere.[155] While we cannot explain the drop in patenting disposition with full satisfaction, we can be very sure it has taken place and in vast proportion, from the statistical as well as logical evidence.

[125] A glance at foreign patent history would show that a similar and about equally profound falling off in the ratio of patents to invention has occurred in every advanced country, and with remarkable conformity as to time. Alike in America, England (table I), France, Germany, Canada, and later in Japan, we find a steady rise of patents to about 1860, then slower to 1920, then stationary for a while, and lastly falling, with the American peak in 1929. But Stafford using a fitted curve locates our peak in 1914.[156] The smoothed course of patents to Americans is shown in our chart 1. Especially in other countries it is the world's invention and patenting, rather than the particular nation's, that are involved, because it has long been customary abroad to patent a worthwhile invention in several countries.[51] From the similar course of patenting in the various countries it follows that the causes, whatever they are, of the great decline in the patent/invention ratio, are not particularly American, but related to modern, world culture.

Patents That Are Not Part of the Patent System

[126] In assessing the surprising depth of relative decline of the patent system, we must further take some account of the probably rising and considerable share, perhaps now one-third, of the patents nominally in force, which are really not part of the patent system. To distinguish them we shall require a definition of the patent system. Though the writer dislikes definitions in social science, let us offer, since we must, this one: The patent system includes all the patent laws, customary breaches of them, the folkways, patent lawyers and

other personnel, the activities of inventors and executives spent on patents, the litigations and all else that goes with patents as an effective means of acquiring and preserving a *private, commercial ownership* of inventions (or more accurately, the legal right to exclude others from them by infringement suits), for commercial purposes, transferable for some such period as 17 years.

[127] From this definition it would follow that nominal patents owned by the Government,[158] or licensed to it as almost the only user, 2.45% of all in nominal force in 1954 and 3.9% of those being granted, are not part of the patent system, though they have connections with it, and some have commercial uses not sold to the state. A patent gained commercially and then sold or licensed to the Government might have served a commercial purpose; yet it now falls under eminent domain and a sort of award or compulsory license system. The foregoing 1954 data, from Forman, show 897 patents issued to the Government in that year, and 597 assigned to it. In 1956 Sagendorph [159] says there were 21,000 or more patents owned by or licensed to the U.S., or at least 2.8% percent of all. Partly to be counted out, as not held in the commercial, profit-maximizing manner, would be about 780 patents owned by universities and 280 by foundations [160] Next come patents subject to compulsory license by court order, 4.9%,[161] or ordered free to all, 1.2%,[161] since on these the nominal owner, the patentee, has no ultimate right left, over who shall be licensed, nor full right as to the terms. Such patents were part of the patent system while the invention was a-making and until the court order, but not after that. We might count them as two-thirds in the patent system, and one-third out, or 2.4% out. We have mentioned private patents on which the Government has a license (on its own terms) and supplies the principal market; they include all military, defense, and atomic inventions and some others. Further to be listed are trade association patents, purely defensive patents, and all recognized as invalid or impotent, perhaps a fifth of all, although only 1% have been fully litigated, with three-fourths of these knocked out.[22] Finally, there are the numerous unused patents which nobody ever wanted except the misguided inventor and his attorney (¶ 116). It is so hard to count these, and to say whether they are a part of the patent system, that we shall ignore them. They were doubtless commoner in past times than now.

[128] All in all, rough calculation indicates that around a third of our 590,000 patents in nominal force are not part of the patent system according to our definition. They really should not be counted when we talk about the magnitude of the system, because the patent system implies the commercial ownership of inventions, which those nominal patents do not give. They usually impose no serious restrictions on the use of the inventions, nor give any important reward to the patentees, although they may serve more or less of various useful purposes. The percentage in 1880 of patents not part of the patent system may have been smaller than today. There were no Government nor compulsory-licensed patents then, and less of trade association, university, purely defensive or known invalid patents, but more of the useless type.

[129] Note that under our definitions, "patents", meaning the count of patents, and "the patent system" are two different things. Either one could advance while the other declined. So we have just spoken of the probable growth of noncommercial patents as not being a growth within the patent system. And in ¶ 116 we spoke of the rising quality of patented inventions as tending to spell less decline in the significance of patents than in their numbers.

[130] And now a few words of summary and warning, before we leave the subject of our graphs. If one took them uncritically, as accurate measures of invention, despite all our warnings, it might seem to follow that by now the patent system could motivate at most 3% of American inventing, and even this little only on the certainly exaggerated supposition that *all* our inventing in 1880 was called forth by patents. But such an inference would ignore all the uncertainties and noncovered factors tending both ways, which we have been acknowledging in the previous sections, in criticizing our indices to forestall critics. There was the relative decline of the humbler, less recorded and less scientific invention, the increasing element of pure science in our indices, and the fact that modern patents (when not of the nominal or invalidated types) are of higher quality and significance and probably of wider scope than average oldtime patents. It may be possible for a modern firm to take much fewer patents, and yet still be able to control a whole new line of production by a few *key* patents. And there are still other considerations mentioned previously that might correct our index both downward and upward.

CHAPTER 4

ATTEMPTS TO MEASURE THE VALUE OF PATENTS

[131] Various significant studies [163] of this problem have lately been made by the Patent, Trademark and Copyright Foundation,[164] especially through the work of Drs. Sanders, Rossman and Associates.[165] They find among patents now in force and assigned, only 21% of the inventors answered Yes to the question: Did you devote your attention to the development and perfection of the know-how because of the patent protection on the sampled invention?; 19% indicated the patent was a factor but not essential, and 70% that it made little or no difference to them. The related question: Would you have manufactured, used, or sold the invention, if you did not have patent protection? brought similar responses: No, 30% of the specific answers; Yes, 70%. The patent requirement for working was most frequent for chemical inventions (44%), then for mechanical (27%), and least for electrical (20%). Again on the development of know-how, a patent was called essential in 17%, 28%, 5% respectively, incidental in 18%, 18%, and 20%, and unessential in 67% 54%, and 75%. Among the two-thirds of assignees giving specific answers as to whether they would have developed the invention without patent protection, 30% said No (or No with reservations) as to the 1938 patents, 28.3% for the 1948 patents, and 22.8% for the 1952 patents, suggesting a declining importance attached to patents. About 75% of the assignees replying [166] said the patent was of some business use to them, and 57% had been worked or were expected shortly to be. The smallest companies had the largest percentages of working (73% of assigned patents), and of marked boosting of sales, while the largest companies realized the best reductions in costs.[167] The one-third reporting a gain from current working, over the cost of producing the invention, named an average of $600,000 per patent, a figure which would probably be doubled by future use. From patents worked formerly but not now, 63% reported a net gain averaging $72,000. But among those reporting a net *loss* from the patent and invention, the losses averaged $88,000 from those presently worked, and $14,000 from the quondam group. On those about to be worked, the losses averaged $12,000, and $4,500 on those not expected to be worked. Among the never worked nor to-be-worked patents, 41% have proved useful in some way or are expected or hoped to prove so. But it is quite a question whether these questions were representatively answered, correctly understood, and reported on the questionnaire without exaggeration, as the authors concede. One should also point out that these values claimed are from the invention, not the patent, very different affairs (cf. ¶ 407). The economic benefits (or losses) from an invention or an attempt to make one are impossible to measure, because they derive from all who attempted it, and from all its users direct and indirect, its influences on capital, etc.,

and its effects will presumably continue while mankind lasts, long after the patent has run out and the firm and the particular need have ended.

[132] Tuska in Study 28 [168] gets an idea of the value of the patents of the more successful independent inventors, through analysis of court findings on those whose patents were adjudicated for some question of property, patents that had been licensed to others, rather than assigned as is usual from employed inventors. Seventy-nine court cases involved a median of 2 patents but an average of 5.8, and among these, 62 cases were affording a yearly mean royalty of $34,000 per year, or $7,350 per patent. Kahn [168] adds other evidence on patents' value to corporations.

[132.1] Edison, the world's greatest inventor, took about 1,000 patents, claiming as his all from his laboratory; but the president of Thos. A. Edison, Inc., once stated that Edison had spent more money in obtaining patents and then fighting in their support than he had ever received from his patents as such.[254] We shall see that Edward Weston (¶ 268), after taking about 300 patents, practically stopped. Machlup [255] says modern thinkers reject the idea that patents' rewards are commensurate with their merits. Patents have been said to be chiefly valuable in rapidly expanding industries.

[132.2] A normal patent reward, if the concept has any validity, has been said by a patent writer, Toulmin,[169] to be around 20% of the sales price of the article, citing court awards; but these seem to be usually less, and our other data would hardly support so large an estimate. A royalty is further attractive from its regular income, with no further sales expense. In any case such a "normal patent reward" is by no means the same as the average reward from a patent. The former figure is gross, the latter net, after deducting all the expenses and personal time spent in making and protecting patented inventions made for the sake of their patent, counting in the unsuccessful patents along with the successful. We may also remember that a royalty is collected only on a minority of patented inventions; the majority, whether worked or not, are never licensed to others, unless to an original or later sole assignee.

Evaluation by Corporations

[133] It seems best to make a couple of fresh starts in our effort to quantify the importance of the patent system, although still maintaining that our calculated catastrophic fall in the ratio of patents to inventive effort must signify a momentous decline in the importance of patents, presumably to a very minor role in the motivation of invention. Suppose we went to the corporations' financial reports, to see what values they attach to their patents.[169] Hardly a student of this subject has done so; most companies do not publish any valuation of their patents, nor list their royalty income separately; but some do, more or less distinctly, and we have gathered in table 5 the findable data on royalties received, by the 16 companies which furnish it and hold more than 500 U.S. patents apiece,[170] plus another company that came to hand. The years are nearly contemporary and the latest at hand, save in the indicated cases where the royalty data stopped earlier. A similar but different group set a valuation on their patents (mingled often with copyrights, goodwill, etc.), which

came to something less than $800 per patent. But little weight can be given to these capital, not income valuations, because the companies would be inclined to understate them, both for conservative bookkeeping, and to reduce taxes now that heavy income taxation makes more profitable to "expense out" each year's outlays for inventions and patents, than to show these as capital assets acquired, on whose cost income tax would be payable. It would be interesting to find such reports before 1940 or 1913, when income taxes were much lower. But as to *royalties received* from patents the companies would seem to have no reason to alter their reporting; so we give it in table 5. But their true patent income received must be considerably reduced by patents bartered for cross-licenses, or to a pool, instead of being licensed for cash.

[134]

TABLE 5.—*Patents held and royalties received by American corporations with the most patents*

[Calculated from Federico, and *Moody's*, NOTE [170]]

Company	Patents held	Designation: Royalties or as stated	Royalties per patent held	Percent of gross income
Average [171]	1,084		$1,223	1.604
Total—17 corporations	18,487		22,613,000	(1)
American Cyanamid Co	2,872	Royalties, licenses and service charges.	1,890	6.12
Westinghouse Air Brake	2,108	Royalties income	529	4.28
Dow Chemical Co	1,884		860	1.317
Monsanto	1,747		68	.214
U.S. Rubber Co	1,469	Net royalties received	246	.382
Deere & Co	1,233		138	.477
Allis Chalmers	914		509	.98
United Aircraft Corp	821	Net royalties, etc	1,725	1.87
Gulf Oil Corp	770		1,720	.33
Budd Co	758	Royalties income	1,760	6.59
Pittsburgh Plate Glass	743		4,030	2.545
Firestone Tire & Rubber	705		1,232	.697
Sylvania Electric Products	632	Royalties and license fees.	1,186	2.755
Cutler-Hammer	565		111	.398
Stewart-Warner Corp	530		258	1.12
Libbey-Owens-Ford Glass	523		1,639	1.041
North American Aviation	213		16,860	5.91

[1] $1,410,176,000.

[135] The royalties received, from patents the corporation licensed, make no great showing, as Melman agrees,[172] although a better one than the valuations. They amount to $1,223 per year per patent owned, and to 1.6% of the corporations' gross income, about 23 millions for 17 corporations, whose gross income was 1.4 billions. Some fees for selling know-how are included. The companies reporting their royalty income are likely those to whom it was more considerable. How much additional value they derived from the holding rather than the licensing of patents, and from exchanging rather than selling licenses, we can but dimly guess. From the minority of patents reported on to Sanders, the net returns would seem higher than from our differently based calculation [166] (¶ 131).

[136] It has been pointed out [173] that "Although the courts have been fairly adamant in refusing to prescribe royalty-free licensing and patent dedication, this remedy has been used widely in consent

decrees. It is clear that royalties could not have been of major importance as reward structures to those who accepted royalty-free provisions," in the monopolistic industries thus attacked.

[137] In any case the real profit from inventions, patented or not, must inure mostly to the consuming public, rather than to the inventor or patentee. Insofar as there is competition between rival similar lines, each made attractive or cheap to produce by various inventions, the market price would fall till it covered only the costs of the marginal producer, including interest on his capital, and return of his expenses for invention.

Patents' Importance, by Kinds of Inventing

[138] For another approach to our problem, suppose we divide inventions, and such scientific research as immediately serves them, into two classes, an Upper class comprising the scientific and the difficult, and a Lower class composed of those depending on mere ingenuity, common or trade knowledge, and the combined luck of great numbers of inquiries, rather than depending on high learning or laboratory organization, even if very often such inventions are made in laboratories. The lower class of inventions will be far more numerous, as reflected in our previously given statistics from Suggestion Systems (¶ 94). It would follow from those and the Census of Occupations that if all workers outside of farm, service, trade, and financial occupations were one-quarter as originative as those represented by the suggestion systems data, then all the reckoned workers would have produced in 1959 834,000 acceptable suggestions, scarce any to be patented, but many of them inventions. It is a number 17 times as great as all the patents to Americans, and certainly vastly greater than the number of significant, important inventions made by all kinds of people. Now let us forget this reasoning, except for the memory of some large number, and think of our whole lower class of inventions, made not only by those employees, but by all kinds of Americans, in and out of laboratories. We have in our mind a vast number of inventions, mostly very petty. How shall we compare the total weight or value of our two classes of inventions, the lower and upper? Shall we say at a guess that the two classes are about equal in value? Probably as good a guess as any. So we set them down in the following table 6 as each 50% of American inventing, and add a guess that 1% of the Lower class are motivated by patents, although much less than that proportion actually win a patent. Most of them would not be allowed patent by law, because they were a mere change of material, better dimensions, a changed order of procedure, a reinvention, a known copy, a logical inference, etc. And almost all that is legally patentable is today judged not economically worth the expense and trouble, including the lawsuits if one ever tried seriously to enforce his patent (¶ 212). So we make a guess that 1% of these lower inventions are inspired by patents, making a ½% of American inventing here.

TABLE 6.—*Kinds of invention, and percent patent-motivated.* (Guesses).

	Percent patent-motivated	
	In this class	In all inventions
Lower inventions (50%): Commercial and nonprofit, organized and individuals	1	0.5
Upper inventions (50%):		
Organized 90%:		
Noncommercial 52%	0	0
Commercial 48%	67	14.5
Unorganized 10%:		
Noncommercial 10%	0	0
Commercial 90%	75	3.4
Total of invention patent-motivated		18.4

[139] Now for the upper half of inventing. Endeavoring again to quantify by weight, not number, we guess that 90% of it by value is of the organized type, because 64% of patents granted to Americans are already assigned to corporations (cf. ¶ 405). Regarding this organized inventing, along with invention-oriented research, we have also some good statistics [174] permitting its repartition as 52% noncommercial and 48% commercial in the source of its funds. For the extent of patent motivation here, we guess two-thirds for the commercial, and 0 for the noncommercial work. Finally we record guesses as in the table for the unorganized tenth of upper invention, as nine-tenths commercial and three-fourths patent-motivated. The table adds up to patent motivation for about 18% of American invention today.

[140] This figure is larger than one would have deduced from the decline of the patent/invention ratios inferable from charts 1 and 4. Being based on guesswork, let us round it to about a fifth of American invention. And if this be not right, revise as you please our guesses in the preceding table 6. No matter how you revise them, if you bear in mind certain proved quantities, such as the percent of governmental inventing, and make your guesses honestly, you will not come out with a share for patenting much larger than our one-fifth by weight.

[141] Our reference to the decline of the patent/invention ratio is not to say that patents ever in the past motivated the whole of invention, or were ever intended to cover such things as the great mass of trivial improvements, or inventions made by and for the Government. Our calculations and "guesstimates" are merely to give us a surer view of the whole subject, such as should help in our later comparisons of the patent system with its rivals, most of which are adapted to cultivate some of the further fields which patents do not.

Chapter 5

THE THEORY AND PURPOSE OF THE PATENT SYSTEM

[142] We have quoted (¶ 31), as custom requires, the few words in the U.S. Constitution on which our patent legislation and whole system nominally rest. And we have quoted in full the Venetian patent law of 1474 which was its first embodiment, and is still the gist of our American patent law, although other countries and formerly our own have elaborated it somewhat more. Our present law can be put in a nutshell of 27 words thus: Any author of an invention may file a description for publication and secure a transferable right to exclude others therefrom, for 17 years from date of allowance. But to explain for our purposes, not for patentees' or lawyers', the reasons for this law, and its social implications and consequences, so that we may compare the patent system with the rival means for eliciting invention, to see which were best in which circumstances—this must occupy us for the next three chapters.

The Older Philosophy of Patents

[143] Patents began, not with a philosophy, but with practical experience, sounder than the philosophy which arose centuries later, but still not well reasoned, since the system amounted to little for the first three centuries of its use, as we have seen (¶ 29). The philosophy which arose later in the Age of Rationalism was based on the doctrine of Natural Rights,[177] and held that an inventor has a natural right to own that which he had created. Natural Rights doctrines are today abandoned by secular philosophers and social scientists, although still reflected in some religious, popular, and legal circles. For who can say what *is* the natural right, e.g., the right to own what one has created, or the right to make use of the best ideas one can find?

[144] Along with this philosophy of natural rights go three other interrelated ideas much more durable and influential to this day, although easy to disprove and replace by better reasons for having patents. First is the notion that the inventor creates his idea himself, "out of whole cloth," one might say, only more than that, out of nothing. A tailor acknowledges the value of the cloth he uses, but a patentee makes no allowance for the prior art, for his teachers, unless they hold current patents—he picks up all other ideas free. The second notion is that since no one else has ever made this invention before, no one else ever could, or at least not for a long while. It would follow from this and the first idea that the inventor who gives the world what it could not get without him, is entitled to its whole value forever, or at least for 17 years, and could not possibly overcharge us for his services. If he asked more for his invention than

we should gain from using it we would decline to use it. The third notion is that the inventor makes a voluntary bargain with the public by patenting his invention and thus revealing it promptly to the world, in return for a monopoly in it for 17 years. For he has an alternative, they say—he can practice the invention secretly, and keep all the profits the same as if he had patented it, and perhaps for longer.

[145] These three related notions are today abandoned by economists and most independent thinkers on the rationale of patents, yet are still repeatedly expounded by patent attorneys and other defenders of the system. We can quote Ballard,[178] Wigmore,[179] Langner,[180] Folk,[181] Robert E. Wilson,[182] Deller,[183] and Dienner,[184] not to mention, Justice Roberts in a Supreme Court decision,[185] Daniel Webster,[186] and the old-time philosopher Jeremy Bentham.[187]

[146] The refutation of these three ideas basic to conservative patent philosophy is very easy, and must be done over once more because of the prestige, apparent logic, and tirelessness of their propagandists. If the particular inventor gives us what we could never get without him, there could be no duplicate inventing. Yet nearly simultaneous discoveries of the same invention are so common that they are the usual rule.[188] One might cite Ogburn and Thomas' list of great duplicated inventions,[189] or better, the daily grind of the patent business. Van Deusen [190] says that two-thirds of patenting attempts are dropped before application, usually at the attorney's suggestion. Then 43% are dropped in the Patent Office stage. The reason in most of these cases is discovering that the invention has been anticipated by someone else; or that it is so logical and easy a development from the prior art that the Patent Office or courts would hold it unworthy of a patent. For they are well aware of the frequency of duplicated invention, and have a legal and commonsense doctrine that a patent monopoly should not be granted for "inventions" so easy that we should get them anyway, without patents. Of American patent applications, about 2½% are drawn into Interference proceedings, because two or more duplicating each other (at least partially) appeared in the Patent Office during the 1–5+ years that one of the patents is pending, or within one or two years thereafter. Then after issuance come court tests, from which we can calculate (from ¶ 46) that about 48% of the patents litigated to a conclusion are thrown out because of anticipation or for "want of invention", which means being too easy, logical adaptations from the prior art. Now to put together the percentages of survival above cited, viz $\frac{1}{3} \times 57\% \times 48\% = 9.1\%$. The product comes out something like 9%, surviving these tests for duplication, of the in-

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[178] A patent is *not* a private privilege carved out of the public domain. So, far from being a means of taking something from the public, a patent is a means of getting something from an individual and giving it to the public. . . . He may, if he chooses, keep it a secret and practice it to his own profit." Wm. R. Ballard, gen. pat. atty. for AT&T, quoted by Folk (ftN *181*), from *Bell Tel. Mag.*, Nov. 1941.

[179] A patent "takes nothing from the public, but gives it something it did not possess before." Lawrence Langner: We Depend on the Inventor; *Atl. Mo.*, July 1942, p. 22.

[181] Geo. E. Folk, long chief pat. atty. for AT&T and patent defender for the Nat. Asn. of Mfrs., in his *Pat. & Indus. Progress*, quotes Ballard as above. 303 pp., 1942, p. 79.

[182] "A patent right however covers something discovered or created by the individual and is a natural monopoly as long as he can keep it secret." Research & Pats. (N 201). p. 178. Dr. Wilson is an eminent chemist and late Chmn. of Std. Oil Co. (Ind.).

[183] "The inventor takes nothing from the public; on the contrary he gives the public something which he has discovered." A. W. Deller: An Inquiry into the Uncertainties of Patentable Inv. and Suggested Remedies; *JPOS* 38:152–79, 1956, p. 158.

[184] "There is no inherent sin in the patent monopoly, because it takes no existing thing from anybody." Jn. A. Dienner: Discussion of Davis & Vaughan in *Am. Ec. Rev. Proc.* 38:251–7, 1948, p. 257.

ventions originally brought to the attorney's office. Many others must have been eliminated *before* that stage, because the inventor had discovered before he got to the law office, that his bright idea was old stuff, or too logically based on the old to be patentable. In short, it would seem that around 91% of inventions are duplicated, at least by starts; incipient inventions, that could and sometimes would have been carried through to patenting and fruition, if the evidence of their anticipation, either fully or in the essentials, had not come to light. Duplication is normal with modern invention. Q.E.D.

[147] If a patent attorney really believed the classic theory he so often expounds,[191] he would tell his clients that they have no reason to search the prior art, nor to hurry to the Patent Office, nor to fear receiving from it a "prior reference," since inventions are never duplicated. And if the Office should nonetheless refuse them a patent, he would tell his client he had lost little, since he could still practice his invention in secret, say an improved mousetrap, keep all the profits permanently, and no one but him and the mice would ever know of it.

[148] We have not before criticized this third orthodox basic idea of patents, that a patent is a free contract, by which the inventor gives up his right to practice his invention in secret, in return for a 17-year legal monopoly. A few words should be enough to minimize this theory, a few reminders of well known facts. The inventor has no such possibility of secret working, save temporarily, and in a few *process* inventions, mostly chemical, and finally with inventions so poor that one may contemplate secrecy with *non*use at least for the present, as the alternative to patenting. This is chiefly the case where a manufacturer has a preferred method, and expects to continue it. It is impossible to practice secretly and abundantly any transportation device, or any product sold to the public or Government, or anything too big to hide behind walls, nor, despite a nominal legal protection, a secret known to many workmen. One of the older writers gave a good formula in four syllables for breaking open a secret process: "A pint of beer." We shall speak later (¶ 272ff., 419, 425, 582ff.) of the problem of secrecy in the chemical and temporary situations where it does exist, and of the sale of know-how, i.e., many little, unpatentable details which *could* be worked out or found out, but which are easier and better purchased. With almost all patentable inventions such secrecy as patents break down, must be dismissed from our thinking as no large possibility save temporarily and anent details. In general, the inventor has no alternative to *publicity-and-use*, with or without a patent. Having no alternative to publicity, there is no bargain with the Government, and no rights of the inventor therefrom, but only such privileges as the Government has chosen to give him, in order to stimulate his precious activity.

[149] A devoted and intelligent defender of classical theory on patents might respond that while he has given up the natural rights theory, and will concede that the prior art helps the inventor, still there is no need to acknowledge nor pay for this last (unless currently patented). And he may concede our last point too, that long secret use of an invention is almost always impossible, so that a real bargain with the Patent Office is rare; and he may concede too that inventions are usually duplicated so that the particular inventor is replaceable. But this intelligent defender still would insist that *unless* there were a

patent reward in prospect neither the first inventor nor any of his rivals would mightily strive and spend to create the invention, which therefore would not be made. I.e., conceding that the invention does not depend on the particular inventor, still it is due to the *class* of inventors, who must be rewarded to function. Also, since the patent reward is most uncertain, there must be large, excessive prizes to make up for the numerous failures. Furthermore, there is value in procuring ideas now rather than some years hence, and the patentee is the one who gets and gives the idea soonest.

[150] These points we in turn concede, except for two: that the inventor's reward must be by patent, and that an inventor necessarily performs a considerable service by being the earliest with a good idea. But first a little story, a parable to lighten our ponderous argument and sharpen our perceptions. In disputes over logic, it may help to apply the same logical formula to entirely different subject matter, to bypass preconceptions.

> **[151]** Having some little-used land in my back yard, I bought lumber and engaged a carpenter to build a garage thereon, promising to pay him what the job was worth. When he had built it, he announced that by way of payment he would take the whole net rentals of the garage for the next 17 years. I protested and he explained: "Before my coming hither only useless lumber lay upon idle land. I alone transformed these profitless things into a productive garage; so the garage is my creation and my natural right; but being magnanimous I will give it to you after 17 years." I replied, in speech ennobled by my choler, "Thou arrant four-flusher! Before thy coming I had provided vital elements for the garage, in the lumber and land. Thy contribution was only the missing labor and skill, which any carpenter could provide; so thy proper fee and thy only recompense shall be a carpenter's hire for the time such a job requireth; take thy guerdon and begone!"

[152] Evidently the case hangs upon the *degree of certainty* that a carpenter (*sc.* inventor) will perform within the expected time the constructive work he is hired to do. Or in other words, are his services personally unique, irreplaceable; is there no labor market from which a substitute could be hired? Or is the inventor a standard professional man, usually a chemist or engineer, or one of the technologists familiar with a certain branch of industry, who can be counted on to turn out some sort of useful invention, and who can be hired in sufficient numbers by rewards sufficiently high, just like the designers and draftsmen who are likewise indispensable for invention, as a class, but none of them indispensable individually? Without food we should die; a waiter brings us food, so how much should we tip him? If he was indispensable for our life, $1,000 would still be stingy; but if there are other waiters and ways to get food, we reason that he is a worker of a certain grade and scarcity value, so deserves a living suitable to his class and no more, and by economic law must under competition get that much and no more. Similarly with garage carpenters, draftsmen, and inventors—if our philosophy can rise to as much sense as our everyday observation and action, we must agree that all of those doers alike are individually dispensable although necessary as a class, that each takes materials supplied him and works them up into a

partly new, *ad hoc*, partly standard product, and the proper reward for each is just enough money and other psychic income to recruit enough and good enough workers for that profession, according to the conditions of the labor market and the principles of economics, including the actuarial principle that where many failures are unavoidable, the prizes must be correspondingly augmented. We have still to answer the questions of how the award should be paid (e.g., by a salary, or by the gamble of a patent), and by whom to be paid.

[153] Our intelligent objector may still not be satisfied that the hiring of inventors can guarantee in advance the production of inventions to fulfill specifications, the same as designers and architects can promise the outcome of their work. One might cite dicta that nearly all inventive ideas fail, and that even among inventions that look so good as to be patented today, 40% are never exploited.[132] True indeed. Yet further economic principles, about actuarial worth, or the reckoning of chances, may be adduced to save our principle. An architect may not turn out the house expected, but something different, as good, or better. A physician may not produce the expected diagnosis and cure, yet do all the better; or he may even fail badly, yet it was wise to engage him, at his standard rate per hour, and take our chances on his achievement. An inventor engaged to solve a particular problem is very apt to invent something else good instead—or to fail fully; yet actuarial economic principles justify hiring him, and at a rate determined by his time, brains, and scarcity, not by his product, the unpredictable outcome. And now if we engage not one inventor, but several, or several hundred, as in the governmental and corporate laboratories, and assign to each not one problem but many over the years, the statistical principle of large numbers will refine our chance-taking into the regularity and near certainty of ordinary industrial activity. Both chance and the individual disappear, and economic or military gains appear, predictable in value if not fully in nature; and whether patents figure or not, the proper and inevitable reward of the inventors becomes determined in the same way and with the same certainty as with the other professions. To be sure, patent values are less predictable, and therefore frequent excessive rewards are needed to counterbalance the deficient ones.

[154] Since rewards are sufficient and effective in proportion to their appeal to the worker, and various rewards are possible for inventors, not just patents, suppose we were to ask them what they prefer. The better ones, the salaried engineers and chemists, reply: Give us a good salary, whether from industry, Government, or what source, we do not care, and good working and living conditions. Patents, or a small chance at big rewards, we don't want; let the employer take the chances, patents, profits, losses, and manifold worries; what we want is a good job, promotion according to how productive we seem likely to be, and some credit, and often a fixed nominal fee of $1–$100 for each patent.[192] To be sure, 40% of those replying to Rossman's questionnaire said they would be encouraged to produce more inventions by more cash payments, bonuses, and royalties.[192] But who would not like a bonus, such as a thin slice of profits if any, and say he would do more for it? *Demanding* such terms is another matter. So these salaried inventors assign in advance to an employer patent rights they might have kept—had they the big money, the gambling disposi-

tion, the connections, and everything else it takes to exploit inventions by modern organization. (See ¶ 321.)

[155] Really, though, we should not call those hired scientists, etc. "the inventors." They are only a part of the inventing team, along with their mechanics, librarians, clerks, *et al.*, the employer who organizes and pays them and decides their goals, the scientists and professors who outfitted their minds, and many other folk. These diverse contributors cannot all be paid in the same coin. Many enterprisers and a few freelance inventors will accept payment in patents, highly speculative unless you can average the chances by holding 100 or so. All the other parties must be paid off with other values, the favorite being some steady source of income. (N 193 and ¶ 521 ff.)

The Economic Theory of Patents

[156] Having placed on trial the classic view of patents and found it mostly fallacious, let us now take up the economic theory of patents. It has always been accredited along with the dismissed theories, and is not only much more satisfying intellectually, but will better support the institution, explain what it is like and how it got that way, and afford many suggestions on how the system might perhaps be modified for the better [194] (particularized in chap. 10).

[157] What class of thing is the patent system? [195] It is an economic institution, adopted to serve economic ends; therefore it must be judged and appraised by economic (and occasionally other social) criteria. This applies to whether each several invention and class of inventions merits patents, as well as applying to the whole system. The patent system involves legislation too, and can be studied as a branch of Law. But one cannot study what kind of laws were best, i.e., go into Jurisprudence, and stick to Law; one must bring in Economics, Sociology, Psychology and other lights, to see what kind of patent laws would best serve.

[158] Next most fundamentally, the patent system is an economic institution involving monopolies on inventions, limited to 17+ years. Yet in most of our economy we disfavor monopoly. And not only disfavor, but fight doggedly, and call the struggle against it one of the greatest issues of contemporary politics. Patents are often extended in effect beyond the inventions patented, in which limited monopolies may be quite unimportant or wholly beneficial. They tend to create *industrial* monopolies of unlimited duration, when gathered by dozens or hundreds in pooled, trust, or great corporate hands, the valid and the bogus patents bundled together, forming a frightening barrier to all competition, a monopoly against consumers of the goods, and a monopsony to the freelance and foreign inventors, who find no market for their patents but this monopsony, this pool. The longrun nature and effects of patent monopolies may be very different from the short, 17-year run intended in the grant of each single patent; and this big, longrun monopoly effect may be quite undesirable, although it still encourage inventing and patenting.

[159] To this situation different thinkers respond according to their lights. Those with legal learning try to draw fine distinctions, as to how far the monopoly in a patent may and may *not* be extended toward monopoly of the industry. We respectfully leave these questions to their many writings, in the current series and elsewhere.

Judges lash out at patent-fostered monopolies, canceling their patents in great blocks, or more often imposing a system of compulsory license to all applicants, at royalties to be set by the court, failing agreement. This is an institution essentially different from the patent system, although it uses patents. It has recently been installed by court order or pressure in wide sections of industry, and will be discussed later. (¶ 415, 463–477.) A cynical Socialist might say: What does it matter? Let the monopolies feed on patents as they please: the fuller becomes their monopoly, the surer the state will come to control or own them. A philosopher might suggest that patents are by definition state-protected monopolies, and hence inherently opposed to free, competitive enterprise, at least to some extent; and to that extent our efforts to protect both patents and competition are contradictory and self-defeating. There still remains a real issue, he would say, but not so grave a one as we thought, since in fostering the one desideratum, we must lose the other in part. Furthermore, he would point out that we might avoid conflict of purposes by a more basic view of our aims. We do not desire patents because they are a prime, inherent good; they are only an instrumental good; what we want them for is to get inventions. Well then, we have said there are 16 other means in use today for eliciting inventions beside the patent system, and still others are possible. Foster some of these, more than patents, if you are strongly opposed to monopoly.[197]

[160] The main *raison d'être* on which patents have rested is very simple. We grant the monopoly of a patent (although in general, classic liberal economists rather oppose monopoly, and government interference in business) when this patent, this monopoly and interference, seems likely to do more good than harm, chiefly through rewarding sufficiently useful inventive work *which might not have been done without* that prospective reward, or not done soon enough. And conversely, a patent is unnecessary, and wrongly gives away the people's freedom, to a merely lucky, adventitious monopolist, when it gives him the ownership of an invention *that would have been made without* a patent reward, nearly as soon, either by him or by someone else somewhere in the world.

[161] The repartition of the inventions, into those that merit a patent reward and those that do not, can in practice be done only when the invention is brought to patent application stage, and conclusively only much later and retrospectively, in patent infringement suits. So the Patent Office and the courts struggle to establish general principles for appraising the merit, i.e., patentability of inventions. To do so and assign each individual case is extremely hard, since inventions are by definition ever new and never twice the same.

[162] The general principle that patents should be granted where and only where needed has also always been the basis for granting patents for inventions won by genius, vast labor, luck, or whose success was immediate and great although the invention seemed easy,[22] and denying them to inventions that could have been made by anyone skilled in the art, or that follow logically from already known prin-

[197] Similarly Victor Abramson points out that some hail the patent system as a defender of competition, through its value to some small firms. On *laissez-faire* principles he thinks the effect on size should be disregarded. *The Pat. System: its econ. & soc. basis:* Study No. 26 of the present series, 1960, 25 pp., p. 10, 11.

ciples, or that have been already made by someone else and are accessible. Patents for an idea found by luck may seem inappropriate by our rule, since a lucky chance should not need nor deserve rewarding. But we should remember, first, that some element of luck enters into all inventions (say the inventor *happened* to think of something) save those attained by strictly logical reasoning such as any skilled man would follow, from premises known to be pertinent to the desired end; and such an invention would not be patentable anyway. Secondly, in years of attention to reported inventions by accident, we have observed that the lucky accidents usually happen to the right people, those working longest, hardest, and with the most equipment, even if sometimes directed toward a different invention. The same accident, if it could ever happen to "a man on the street", would probably be meaningless to him, and certainly would never lead him to make and perfect an invention.[198] In short, invention by luck is a regular by-product of inventive talent, effort, and facilities, and hence needs the same reward stimulus as its companion joint-product types of invention. (¶ 473.)

[163] Since Economics does not talk about justice, the economic theory of patents cannot include giving the inventor his rights, or a just reward. This science's only aim is the welfare of the community, in our case chiefly through the stimulation of invention. But economics is not sufficient to answer all problems, and we shall note later various considerations of law, technology, sociology, philosophy, etc., that must be invoked if we are to complete our basis for action.

[164] Under Economics there are, furthermore, certain minor motives for granting patents, for us to consider. There is the service of PUBLICITY, our second justification, spreading the ideas to all the world by the printed descriptive patent, even if the invention be never put in practice. This is surely important; but if the invention is good it will doubtless be practiced by someone, and we have seen that except for a few chemical and other processes it is impossible to practice a good invention long in secret. It is also possible, and often done despite the law, to write patents most obscurely,[199] and to leave out essential details, such as *which* catalyst is best, among many listed as usable. Again, the purpose of patenting calls for *delaying* publicity, until one's application is filed, or longer.[200] And after patent filing there are long delays in the American Patent Office, averaging three or four years today, adding up to a delay of several years, usually, between the making of an invention and the publication of its patent. There are many other ways to publish ideas besides patents, above all the scientific and trade journals. If these usually allowed a delay of several years between achievement and publication, we should think they needed waking up. The prompter use of these and other media by patentees, is indeed one of the chief publicity services of the

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[199] A patent attorney, Eyre, said: "The law as it has been applied and interpreted now sanctions a combination of drawings, specification and claims that is a masterpiece of concealment of what the applicant thinks he has invented and wants to protect. Mainly because of this fact, the system has become unnecessarily complex, technical and artificial." (See N 289, second page.)

W. L. McKnight says that disclosures must be full and correct or the patent is invalid, and incomplete disclosure is one of the first defenses of an infringer. However, only about 1% of patents are ever sued on, so that the incompleteness could be established; the cause of patent invalidations is almost always unconsidered prior art, says Frost (N 221, p. 61); and the 99% unlitigated patents are important. McKnight quoted C. E. Barnes: The Patent System from an Inventor's Point of View; *PTCJRE* 5: 68.

patent system, since if invention owners feel they have their ideas essentially protected by a patent, or even by an application not yet granted, they are more willing to allow publication, and visits to their plants.[201] While good inventions can rarely be practiced long secretly, it is possible and vastly frequent to block information temporarily, especially before production begins, and in minor or latest detail improvements, rarely explained well in patents. Many and important contracts for instruction in know-how, along with the license of patents, are based on the fact that, as Melman[202] and Vernon[203] say, "The information disclosed in patents is often not enough, taken by itself, to be of much use to the receiver." We shall speak in ¶ 274–80 of commercial competition's great countervailing *encouragement* of minor and temporary secrecy, lasting some years, in contrast to the noncompetitive systems for obtaining inventions.

[165] In sum, while patents do a great work of publishing and indexing new ideas, especially those not practiced, it is a work for which other media are at hand, and commonly much quicker, better indexed, and much more used. Furthermore, any competitive system of making and owning inventions entails a vast amount of secrecy. And an invention that can be practiced secretly, can likewise be infringed secretly, cutting the value of a patent on such.

[166] The publicity function of patents could be enormously enlarged if they were granted quickly, required to be clear and full, and if their classifications were brought up to date, cross-classified, internationalized, written in Esperanto or the new dialect Ruly English, and otherwise adapted to mechanized electronic searching, and the search apparatus made available to the public in various metropolises.[204] The Office of Technical Services is making another good start in this informative direction, with a vast file of know-how as well as patents, indexed in 33 cities.[205] Another good remedy proposed (¶ 502) is prompt publication of all applications, later searching and granting as definitive patents only those for which a special and considerable fee is paid.

[167] A third purpose for which patents are used is to defend a firm against other patents.[206] E.g., Henry Ford in his later days started taking out patents, licensing them free to others.[207] A purely defensive purpose is often claimed, but is not always so clear as here, as being the only purpose. In the case of the Government's patents, defense is said to be the main motive, as Forman explains in seeking to justify the 14,626 current patents the Government held in 1954.[208] Davis thinks that as many as one-third of all patent applications may be for defensive purposes.[209] So Senators O'Mahoney and Wiley introduced a bill to provide a quicker and cheaper way to satisfy a defensive purpose, and one relieving the Patent Office of its chief burden, by allowing prompt publication of an application without completion of examination nor grant, when the applicant requests this and the Commissioner approves.[210]

[168] In many cases a patent called defensive is sought as a bargaining counter to force concession of licenses from other patentees. This is really a variation of the first and main motive of patents, only paying off in another way.[211] Instead of using one's patent to exclude, one trades off the threat of this in order to get rid of patent barriers. While useful to the grantee, such a patent does not add sup-

port for the patent system; it is using a patent to get around the effect of patents. Cf. ¶ 504.

[169] The fourth economic justification for patents is to *prevent* many inventions from being used, despite the popular, uninformed idea that the suppression of inventions is a great count *against* the patent system. The plain fact is that most inventions, even about half of those still being patented, are at a given time bad ones, inferior ways of doing something, or ways to do something not worth thus doing, and they would not be utilized at that time in the absence of a patent system. But when the best way is patented by someone else, a competitor may find more profit in using an unpatented inferior method than in paying for a license on the best one (supposing its patentee will grant one)—especially when the patent is only on a minor step of a big production. So it may pay the patentee of the best way to protect or buy up the inferior methods also, thus preventing their use by any competitor, and either licensing the best method on royalty, or keeping all for himself. In these cases the question arises whether we should try, as all other countries have, to weaken industrial monopoly by a Compulsory License law. It is a big question, which we take up later (¶ 463ff.). We must likewise defer consideration of the great popular myth, that good inventions are suppressed by use of patents; both reason and authority deny this much importance (¶ 304). In any case where the invention is an inferior one, that would not come into use in the absence of patents, the technologic economic interest of the public calls for it to be suppressed, out of use, but yet not out of mind, published and available in case changed circumstances later make it worthwhile, or in case someone gets a good idea for modifying it. To accomplish the useful ban on use, given our present patent system we have no instrument but further use of patents, to cover and smother the inferior inventions and to give the whole production to the best.

[170] This fourth proper purpose for patents is, like the third one (defensive patenting), a way of using patents to overcome some of the misuses of patents, combating evils that would not exist but for patents. Every law creates evils, including waste of energy in struggles to get around the law. A law can be justified only by doing, on the whole, more good than harm, and by yielding a larger such surplus than can be expected from any substitute arrangement.

[171] It is often and well said that a great benefit of patents is to give protection for the long and costly *developmental* period of an invention, after its basic patent has been applied for, and while its details, design, production, markets, and advertising are being worked out, often at much more cost than the original invention. Without patents most of such work could be seized free by imitators, as well as the original idea, as soon as the invention's value was proved. This service of patents is really a special aspect of our first, main justification, viz., that patents elicit useful work that would not be done, without the prospect of that (or some substitute) reward.[113] It is

[113] This helpfulness of a patent for the developmental period means that the patent's protection is extended to cover *other* inventions, perfectings and discoveries not specified in the patent, not yet devised, and mostly unpatentable by law. That everyone approves this stretching a patent is a point to remember, if we later wax indignant over the stretching of patents in scope, in denouncing industrial monopolists, or "crafty" patent lawyers trying to sweep up other people's developments by a "dragnet" patent. Yet there is a big difference, in that those people are grasping at the work of others, while our patentee of an invention under development is seeking only protection for his own useful further work. It is an economic difference, and points up again that patents must be judged by economic, and not by primarily physical nor legal principles.

a consideration which points out a large additional cost in the overall innovation process, and shows a large merit in the patent system, for its meeting all these costs.

[172] A fifth occasional justification for patents is to protect the public interest by controlling quality through controlling production. This motive is stated by some universities and foundations producing drugs, and might likewise be claimed by some pharmaceutical and other firms. One might class as a variation of it the legitimate part of a few companies' insistence that only their products, mutually suitable, be combined in the user's aggregation. A patent monopoly is not the only means by which quality can be upheld, nor a sure means, but it can be a handy one.

[173] A sixth and small reason, probably a leading one for taking out governmental and other noncommercial patents, is to secure some honor for the inventor, and/or his firm or organization, and to provide some measure of their achievement.[214] Westinghouse says its inventors set great store on their patents. Similarly, on a soldier's sleeve we set rank chevrons, wound and service stripes. Inventors surely desire and need honor as well as pay, and a patent is one way to provide it. Yet patents are not available for most inventive and research work, (chap. 6), nor are they well quantified, since they differ greatly in significance; nor are patents conspicuous, since they are not worn on the sleeve, stationery, nor anywhere, but are matters of record known to few. Some nations give civil decorations for important services. The Russians give special privileges to inventors, American professional societies and universities give medals, degrees, prizes; our patents serve this purpose too, but not well nor importantly. We shall suggest in chapter 10, section 12, some perhaps better ways to fulfill this sixth purpose of patents, the honor and appraisal of the inventor.

[174] An economic reason advanced for patents, especially in countries of small production, is that granting them to foreigners leads to introduction to one's country of new industries.[215] So it may happen sometimes; but we reject the justification as invalid, first, because it is motivated by mere protectionism; second, it may instead lead the foreign patentee to manufacture in his own country and sell in his patent-protected American market; and third, because whether he produces abroad or in America, we must pay royalties if we give a patent, but can use the invention free if we do not and can get the information. On the second point, some countries attempt to require "compulsory working" in the patent-granting country, under penalty of cancellation, or compulsory license to a domestic firm. But this law is never very effective, and would be particularly inappropriate in America. For our tariffs give more than enough inducement for foreigners to produce inside America, and we always practice free trade in capital, i.e., grant full freedom for foreigners to make profits here and retrieve them home, and the capital too. So they will certainly install American production if it be economically warranted. Patents to foreigners can be soundly justified only by the principles of reciprocity for American inventors, and by our other seven motives for patents in general.

[175] The seventh and last economic justification for patents is that they are often needed to get enough concentration of production, Spencerian integration, for enough of the advantages of large-scale

production. Patents accomplish this very neatly, wherever they work, since control of the patent gives control of at least what firms may work the novelty. If and when it becomes economical to work the invention in more than one place, the patentee will presumably do so, either starting a duplicate works himself, or licensing someone else to do so, under limitations.

[176] How much concentration of manufacture is needed varies widely among inventions, chiefly by the principles that the smaller the production must be, the more objectionable is splitting it up among competitors; and by the principle of Prime Costs. The larger the share of prime costs in the productive process, for setting up working drawings, molds, dies, special machines, assembly lines, and scarcely convertible buildings, and the less completely this overhead is occupied by the given production, the stronger is the case for concentrated, even monopolistic rather than small-scale, competitive working. This is why, even without regulated patents monopolies are universally acceptable in the case of copyrights, railways, and pipe and wire utilities. The application of this principle of patents, with such wide variation between inventions, should be determined by economic, not ordinary legal considerations. For instance, in the making of common pencils, unlimited competition were probably desirable, but for typewriters, with their smaller production and expensive tooling-up, probably only a few competing concerns were right for standard machines, less for portables, and only one for a portable machine with variable type. The same considerations apply to our fourth purpose of patents, that of preventing use of inferior inventions.

[177] If and where the patent system is replaced by any other means for securing invention, it were well to take care of this seventh purpose. Invention by a government, university, foundation, trade association or award system may meet every need but this one, supposing that someone has carried the invention through the long and expensive developmental process, to the stage of perfected use, as noted under the first purpose, and then drops control of the completed invention (¶ 521). And so, too, under compulsory license, which our courts have latterly been imposing wholesale in antitrust cases (when they do not open the patents free to all, in effect canceling them). All these provide in themselves no solution for the problem of concentration for efficient production, as patents do. It is a big problem, involving not only the size, location, ownership, and perhaps competition of plants, which we have been considering, but also standardization of products. We shall continue our discussion in the more appropriate context of ¶ 218–221.

[178] A special case of our first economic principle (that patents evoke invention) is mentioned by Reik, in that patents "force industry to carry out research work tirelessly as a defensive measure against being outflanked by competitors".[216] This does not further mean that a firm must necessarily file defensive or other patents; mere publication or public use would usually be sufficient.

[179] Still another and very common case of the first principle is *invention for circumvention*, to get around someone else's patent—"inventing around" it is sometimes called. The social principles of invention, especially the principles of duplicate and of equivalent invention[217] entail that numerous seekers are usually trying to reach

the same goal about the same time, some by identical and some by unlike but also feasible methods, such rivalry being typical of the modern world with or without the patent system. (¶ 146). When a patent has been granted to the first-comer, the later comers do not like to pay royalties, nor to be excluded from production; so if they cannot destroy the first man's patent in the courts, or if they shun the great costs of litigation, they try to circumvent his patent by some equivalent invention; and if they can also get a patent on this, so much the better. The rivals not only tend to start work about the same time, as we said, when evolving technology makes the situation ripe for that invention, but also the first one to make his ideas known sets off his rivals. Even a patent can by no means monopolize all of an invention, its idea-elements, e.g., that a particular new function revealed is worth doing and is doable. A patent can protect only a particular combination of ideas; much the same ideas in other combinations are probably open to use.

[180] For every attack there's a defense; so any of the patentees, especially a wealthy corporation with aggressive or defensive policies, may try to take out the rival, equivalent patents itself first, or to buy them up, as we told under the fourth justification, to own possibly a dozen equivalents, yet use only the best one.

[181] Is all this effort to invent around patents, to find equivalents for inventions, a good or a bad thing, one of the evils due to the patent system, or one of its merits, another variant of the first economic justification of patents? Certainly it is both good and bad in different cases; which side preponderates the writer has no means of proving.[219] The fact that a useful rival inventive effort was touched off by an obstructing patent does not prove that the second solution would not have been produced shortly without that. The mere appearance of the new invention, with its novel merits but particular shortcomings, might well have been sufficient stimulus. Three thoughts suggest a preponderance of waste over accomplishment, and a fourth the contrary: (1) In the great inventive laboratories of government and trusts, to which patents means little, constant effort at improvement goes on, usually aimed against some shortcoming seen in present methods, but occasionally to achieve a new effect, or to find uses for a product thought of as too cheap, under-utilized. With such motives constantly instigating research, the additional motive of patent circumvention would be unnecessary, even if often stimulating. (2) It seems logical that the best method would be a little likelier than any of its rivals to be developed first to the patented stage, because being best, it would probably be perceived as such. (3) The writer cannot recall, nor find in his abundant files, a single case of an inherently worth-while invention which was made in order to circumvent a patent, or to bar a rival patent. Carr alleges numerous cases, but his evidence is suspect.[220] Frost, arguing for circumventive inventing, cites instances, but calls only one,

[219] R. R. Nelson attempts mathematical formulas for determining the appropriateness of parallel efforts, depending on the urgency, etc. An example is the five ways which were started for making uranium explosive, of which three were carried through. Uncertainty, Learning, & Economics of Parallel R&D Efforts: *Rev. of Ec. & Stat.* 43:351–64, 1961.

[220] It is based on about 300 questionnaires returned to Los Angeles patent attorneys from firms and individuals they selected, in a project to test the conclusions of the Melman report (N 165). The question "Have you ever attempted to 'design around' patents?" brought 161 yeses, 57%; but the following question, "Has your own item produced in this manner been: not as good as—equal to—superior to—the patented item?" brought 187 answers, 114 of which claimed superiority. (N 100).

fluid catalytic cracking, superior to the original, and in this case names a fault of the original, costliness, as one reason for the rival effort.[221] (4) On the other hand, great laboratories seeking by the earliest possible date a greatly needed invention have occasionally set at it rival teams, with some communication between them, so that differing means might be simultaneously sought, for quickest finding of the best. On balance it appears that invention for circumvention of patents probably represents a net social loss; but the opposite is possible. Just for an example when Watt wanted to use the long known crank and connecting rod, he found that someone had patented its use in a steam engine. So he devised his "sun-and-planet" gear, an ingenious device, with one definite merit beside avoiding the patent. Yet he dropped it when the crank patent expired, and we have never heard of its being used since for anything, though it very likely could be found in some obscure nook.

[182] And now an observation. While invention for circumvention may be a merit of the patent system in some cases and a defect in others, when we are casting up the general balance we cannot add these two together, viz., that patents help inventors, and that patents can be circumvented. We cannot have it both ways. Yet the same people argue that the patent system is good because it protects one's invention, and is good because it leads rivals to circumvent a patent, by inventing a better way which avoids it. We are reminded of Franklin's defense of his facetious invention of a sundial which at each hour would fire off as many cannons as the number of the hour. He added that another merit of his invention was the great saving in gunpowder that would be realized on days when the sun did not shine.

[183] A brief summary of our seven economic reasons for patents will be given at the start of chapter 7.

Premises of the Patent System, Often Overlooked, Often Questionable

[184] The patent system and its justification or indictment, in its rivalry with the dozen or so other institutions for the support of invention, normally involves a number of usually unexpressed premises or basic assumptions, that are often not thought of, but which appear frequently and are widely enough accepted to have an influence on the structure and administration of the system, even though one must recognize that they are by no means followed in all instances. The thoughts of man and his societies are too complex for that, and also readily harbor inconsistencies. Whether these assumptions be true or false—or better how far they are true—is obviously important for appraising, judging the patent system. Unfortunately, we cannot do much to settle these questions, because this monograph is not the place to argue principles of social philosophy, over which politics has been disputing for a century. But simply to raise the questions should be a service, to the many readers who habitually overlook their existence and priority. Merely stating these premises will raise well-founded doubts as to their truth, or rather the extent of their truth.

[185] 1. That a particular invention can be defined, and that the whole world's used or published prior art can be searched enough to assure that this invention is new.[223]

[186] 2. That a level of invention, a minimum threshold of difficulty, or of difference, can be laid down for all patentable invention, so as to exclude the products of mere ordinary ingenuity or unusual learning or labor.

[187] 3. That the inventor or inventors can be named, and all their helpers, teachers, and suggestors can be ignored.

[188] 4. That inventions are made by personal inventors, and not by the corporations or Government bureaus which hire them, set their tasks and provide everything needed for the accomplishment aside from their minds and labors. Some other countries do not have this premise, but grant patents to corporations or any proper owner of an invention.

[189] 5. That the patentee, if not a corporation, is a businessman, fully able to protect his own interests; and that the market in which he sells his invention or patent is a normal, competitive one, not a restricted, monopsonistic one.[224]

[190] 6. That a chance to make money by the great gamble of a patent, is all the system need provide to stimulate invention in the needed fields.

[191] These last two assumptions are ones whose truth increases with the progress of capitalism, because when patents are gathered into corporation portfolios of dozens or hundreds, their aleatory character declines, by the averaging princple of large numbers, and the business capacity of the patentee improves. But assumptions 4, 7, 8, 9, and 12 probably wane in their truth.

[192] 7. That all patents must be alike in terms, and no distinctions made, simply awarding a patent to every invention and refusing one to every non-invention. The reason for this is the following:

[193] 8. That while private enterprise is flexible, clever, and almost always beneficent, Government is venal or stupid, so that its liberties must be extremely restricted. We want a government of laws, not of men, and so the laws must be as simple and uniform as possible, lest men pervert them, especially bureaucrats and bribers.

[194] 9. But that outside the confines of the patent law businessmen should be left free to do practically anything they wish with their patents, patenting, and inventing. Only the monopolization of an industry by amassing patents is to be interfered with.

[195] 10. That when permission to use a patented invention is needed in order to work another patent, *or for any other reason* of public benefit, the patentee can be trusted promptly to grant a license, or to work his patent himself, at a proper fee and in proper quantity and manner, in his own and the public interest. That patentees never fail in wisdom, capacity, or obedience to law.

[196] 11. That the patentee's private interest always coincides with the longrun public interest, according to the standard assumption of *laissez-faire*.

[197] 12. That patents are infallible and inviolable; or at least that if wrong be done, a court trial and perhaps a retrial on appeal will repair the wrong and social damage that had been done.

Chapter 6

PATENTS PROTECT ONLY CERTAIN TYPES OF INVENTIVE PROGRESS

[199] Either by legal exclusion or by economic unprofitability, the patent system leaves outside its direct jurisdiction, protection, and help, the greatest part, far more than half, of all the activities that we should call invention, beside scientific and other labors that are necessary preludes or accompaniments to invention. To be sure, much of these may be paid for indirectly, through the practical coverage and rewards of a patent, when the discoverer is able to get an enforceable patent on some key phase of his work.

[200] In drawing up table 6 we calculated a guess that patents motivate about one-fifth of American inventing today. We seek now a different approach to a related problem, viz., to list what kinds of invention and invention-helping work are patentable, and what are not. Be it noted that an invention might be patentable and yet a patent be little or no motive in its contriving: this happens constantly in the great governmental and monopolistic laboratories. Or work might be done for a patent motive, even very good and successful work, and yet nothing patentable come out of it. In short, patentability, patent motivation, and patenting are three separate matters, with some tendency to concomitance. We now examine the first, patentability.

[201] Allowed for patent are in general new products, devices, and ways for making material things, bacterial processes for manufacture, new compositions of matter, and a few new plants capable of asexual reproduction, chiefly of the rosaceous family (fruits and roses). A particular artistic design for a usable article can receive a Design Patent for 3½, 7, or 14 years, for fees of $10 to $30. But design patents are outside the field of this monograph and of our statistics. Plant patents are also unconsidered and few (106 in 1961).

Inventions Legally Barred From Patent

[202] 1. Legally excluded are *scientific discoveries*, however essential and even practically sufficient to teach an invention, and all discoveries of the nature of any existing thing, such as a mineral deposit, or the source of a trouble in working a process. But any of these might be in a way patented under the guise of a new apparatus or process for using the discovery, yet with a likelihood that someone else could invent around this patent, thus appropriating the discovery. A sort of patent on scientific discoveries, or rather a compulsory license, entitling the author to collect a royalty on all remunerative uses of his discovery, has been often proposed, but rightly rejected as too bothersome.[226]

[203] 2. *Social inventions*, such as a way of doing business, organizing, advertising, or teaching. The French Revolutionists allowed them patents.

[204] 3. *Artistic inventions*, such as water ballet, or the idea in the *Great Train Robbery* of using the kinetoscope to present a drama. But there are the related and allowed design patents and copyrights.

[205] 4. *Reinventions*, or old inventions, unless the earlier version was unknown to the later inventor, had never been published in print, and had never been used in this country, or had been abandoned before use. A reinvention may be as useful as any new one, like the corrugated firebox rescued by Fox.[227] So some large companies make a practice of looking over their unused patents; [228] American Viscose found 25 profitmakers among 1,000 of its unused patents. One result was a 25% jump in employees' ideas submitted for patent. Yet surely one's own patent portfolio were not so likely a place to discover forgotten but usable inventions, as the dusty records of other companies, libraries, and countries.

[206] 5. *Inventions too logical* to the suitably trained mind, versed in the whole pertinent prior art, or which required for their finding, much hard work, expense, and/or learning, rather than special ingenuity or "a flash of genius", as the Supreme Court once expressed it. (ftN *131*, p. 41). The principle, largely sound, is that if an invention is fairly logical someone is bound to hit on it, so a patent reward is not needed, and would wrongly give away the people's birthright. Thus, in the hard fought case of an invaluable invention, Coolidge's ductile tungsten, for lamps and all other electrical purposes,[229] the courts first upheld the patent, then struck it down and again upheld it, because Coolidge had succeeded in compacting the metallic powder by familiar methods of sintering, swaging, reheating, etc., with which he experimented so patiently that he finally succeeded right where all others had failed. We have set down in the previous chapter the No. 1 economic justification of patents, viz., that they are warranted when and only when they are a reward needed to elicit invention. By this principle the nature of the difficulty, the obstacle to invention, is immaterial; we should only ask if the patent reward might overcome it, and if any other institution would do so better. Whether the obstacle be a shortage of inventive talent, or of brilliant thinking applied to invention, or of mere patient labor or expensive laboratory investigation, or requisite scientific discoveries, or a laborious search among forgotten inventions, should make no difference as to the propriety of a patent reward, provided always that this reward would be likely to evoke needed invention, and that no other system would work better. But this is economic sense, not the patent law, which says that skillful, patient, and costly plugging away, guided by the best known principles of science, is not to be rewarded by patent. To be sure, there are cases which read as if this economic principle had been allowed.

[207] But of course there are various considerations of practical law work to be considered also. To assess the proper reward for turning up forgotten inventions, e.g., might be very difficult. Such recallings are constantly rewarded with small sums under suggestions systems (¶ 94), which hardly ever use patenting. Likewise with

the proposed quite logical nuisance of royalty rights on scientific discoveries.

[208] 6. *So-called immoral inventions*, chiefly ones frankly for gambling or cheating, or for contraception, even though the last has been approved by the courts and by most of our citizens.

[209] 7. *Inventions lacking utility* are declared by the statute to to be barred from patent. But this is usually overruled by the common law which has changed "useful" to "operable", with the result that useless inventions are patented in considerable numbers. The best evidence is that still 40% of inventions being patented are never used.[132] Senator Kefauver would have required for a drug patent proof of serious improvement.[230] There have been fantastic things patented in earlier years. But today almost all our patents on useless and never-used inventions are taken because of a rational hope that they will prove useful; or else to protect from possible competition a better method owned (¶ 169); or are usable for "fencing in" a rival working a different basic method, by foreclosing his possible lines for improving it. Patent attorneys say, with sincerity and truth, that it is very hard, and usually impossible, to predict which inventions will prove useful. But if a psychoanalyst were engaged to investigate their minds, he might discover a subconscious bias in favor of abundant patenting. Most countries sort out later the useful from the useless patents, by taxing them all at yearly rising rates, with the desirable result that 95–98% of the patents have been abandoned before their full term had run.[146] We shall discuss this reform later (¶ 492 and ftN *480.1*), and the rare but particularly antisocial type of useless patent called the *dragnet* type (¶ 288–91). This is on a vaguely defined and scarcely worked out invention, not operable in economic reality, which some sharp fellow files on in a hurry, as soon perhaps as scientific developments have indicated a possibility there. He hopes that others will work out ways to make the invention practical, whereupon he will either appropriate their work, or force them to buy a license. When his patent is granted and published (which he tries to delay), he has done one social service, of advertising the new possibility; but he deprives all others of most of their motive for working it out.

[210] 8. Miscellaneous reasons for nonpatentability, such as faulty procedure, undue delay, new uses of known devices, etc., would make up a long and intricate catalog, of importance in the patent business but of no interest for the purposes of this book. If the reader be curious, he can find many books expounding the patent law, by writers more competent for that.[232] Suffice it for present purposes that the vast majority of ideas useful toward invention, scientific or amateurish, such as are brought forth in both laboratories and suggestion systems, are not directly helped by the patent system. They are either legally barred for any of the reasons in our eight classes, or economically excluded, or rendered of slight value, through any of the five reasons following. Most often both legal and economic reasons would rule out patenting.[233]

[233] Some foreign countries exclude from patentability foods, medicines, chemical compounds, or other classes; but we see no reasons for such distinctions on sweeping bases. All patents have their values, and their social costs. Cf. P. J. Federico: Pats. for New Chem. Compounds; in JPOS 21: 544–9, 1939.

Economic Exclusions from Patenting

[211] American patents cost from $60 up in official charges, plus attorney's fees ranging from thousands, to nothing for handling it yourself, but averaging perhaps $300. Next must be added the considerable cost of time by the inventors and executives cooperating with the attorney(s), and possibly expensive proceedings in Interference with another patent not yet granted, or in prosecuting appeals for a grant. But all this is only the beginning, to get the domestic patent. To protect the invention abroad, more or less of the foregoing must be done over again in each country of interest, and promptly.

[212] To protect the patented invention, in the minority of cases where it turns out worth protecting, will next require constant vigilance as to possible infringers, perhaps secretive, a selling job if there are to be licenses, the teaching of know-how both when a license is conveyed, and later as to improvements, the maintenance of some secrecy perhaps, as to details; constant effort to keep one's patented art up-to-date and advancing, by making, buying or appropriating improvements from all possible sources, such as practice and patents abroad; and finally the prosecution of infringement suits, which is one of the most expensive forms of litigation.[234] Our next chapter will be the place for statistics and thoughts on this subject. (¶ 261 ff.) Suffice it here that patents, and especially their defense and active use by suing infringers, are so expensive and risky a weapon, that almost all inventions and inventors are economically debarred from their use, if not also debarred legally.

[213] Four other classes of invention, important, related to each other, and partly overlapping, should be noticed here, and discussed in detail in later chapters—classes of invention in which patents are allowed, where inventing is little encouraged nor paid for, by patents or any other of our institutions. Indeed, in the second to fourth of these classes the lack of support amounts almost to prohibition of invention, in practical effect. These four next classes are:

[214] Second, *Fundamental inventions*, like the helicopter, print-reading machine, electricity directly from heat, soilless agriculture. Such inventions are so big and difficult, that they take so long to develop from the stage of first patented conceptions to successful and important use, that the 17-year patents on the fundamental ideas will have all run out by the time remunerative use arrives, and there can remain in force only the more recent patents on improvements, not indispensable nor very important, made by other men and belonging usually to companies other than the pioneers. Intelligent inventors and corporations, perceiving the odds they face, against ever being repaid, even after many years, for their great expenses in developing a fundamental invention, almost always avoid such difficult quests. So the fundamental inventions, the most precious of all, are left in almost total neglect, assuring the slowness of their development, the evil compounding itself, and the basic patents a mockery. We shall explain and prove this abundantly later, in chapter 8.

[215] Third, *Custom-barred inventions*. This is a field that could be very great and beneficent, but is almost zero today, because inventions in it meet not only no reward or encouragement, by patents or otherwise, but their success is practically prohibited, by deaf, im-

movable, usually unorganized custom. Examples[235] are: better rail car coupling systems, much needed in Europe; different rail gages, wider templates, contra-standard tracks; and especially inventions in broadcast and other public communication systems which would interfere with standardized features at the receiving end, chiefly in radio and television receivers, phonographs; also the familiar alphabets, signals, musical notation, digits, arithmetic, calendar, weights and measures.

[216] In all these fields nondisruptive additive improvements are welcomed, like the new high frequency channels of radio and TV, and new words and scientific symbols, which supplement without contravening established custom. But even great standardizations have been occasionally broken and changed for the much better, chiefly when a government asserted its authority, as when the Janney automatic car coupler was forced in by American law in 1887–93, in place of the slow and deadly link-and-pin, while thousands of other solutions rested helplessly in the Patent Office. In the Middle Ages Arabic numerals and algorisms gradually replaced the Roman numbers and abacus by the choices of scholars. The change of the Turkish alphabet from Arabic to Roman by Kemal, and of the Russian alphabet, spelling, calendar, and measures by the Soviets, are examples of strong government action, where national consistency was requisite. The blind, whose writing falls under the control of a few schools and publishing houses, have had their raised letters transformed by invention several times in the last century, in progressive departures from the traditional Roman original, with vast benefits. So it may even happen that the blind shall lead us sighted folk, whose alphabet and system of spelling, custom-bound and lacking legal control, have not been much changed, nor improved on the whole, since 28 centuries ago, when the Greeks invented the vowels. To obtain any upsetting inventions, in a vast and potentially invaluable field, consisting largely of every kind of *communications*, it is usually necessary for government to assert its authority.

[217] To distill into a simple formula our observations on custom-barred invention, we should say that the power to invent, or in any way to change things abruptly, is inseparable from *ownership* or *control* over all those things that must be changed to use the invention, including even part of the education, thoughts and activities of those who must use the novelty. If invention be thus inseparable from ownership or authority, it follows that where there is no ownership nor authority enough concentrated to act sufficiently together, no invention can be brought into use, wherefore no one will spend much time nor any money to invent and perfect that obviously unadoptable invention. In still fewer words, without requisite ownership or preempted control, bold invention is impossible. Therefore, considerable areas of American civilization remain century after century without possibility of improvement by invention, namely those areas, chiefly of communication, in which a high degree of standardization is enforced by unorganized custom, no one asserting ownership nor authority. And these areas must always remain without progress by invention, unless and until the American Government asserts its authority for such purpose, as most other nations have done.

[218] We have seen the congressional authority often and most beneficially asserted in fields of transportation, defense, post office, television, and all radio communication, fixing weights and measures, industrial standards and standardizations, drugs, foods, even labor where interstate commerce was concerned, and full authority over the big business of Government printing. The Federal powers from the Constitution, over interstate and foreign commerce, the post office, and all spending or granting of Federal money have been invoked in so many directions and stretched so far, that we can see no constitutional obstacle to extending them to make possible, or even to call forth inventions in communication, in our writing methods or in language itself. Yet the only significant uses of these powers that we recall are the creation of Ruly English in the Patent Office (¶ 166), and the prohibition of progress when Congress overruled a few mild spelling reforms ordered by President Theodore Roosevelt.

[219] Fourth, *Inventions nominally technical, but whose nub is social.* We have discussed under the seventh economic justification for the patent system the important service of patents in providing sufficient concentration of manufacture (¶ 174–7). In the related case to be now considered, there is a lack of any patents sufficiently dominant to give control over a new industry, which yet needs concentration for efficiency. It is a much severer problem and loss than people imagine, because we hardly feel the lack of something we have never experienced. Take the problem of cheaper housing, through prefabricated houses or apartments, or house trailers. All these have never been cheaper than they are now, so there seems to be no problem here, no loss. But they *could* be much cheaper than they are, if they could be fabricated wholesale, hundreds or thousands a day from a few factories properly spotted about the Nation, turning them out from fibered plastics and other modern materials.[236] But this would require immense molds, presses, and automatic machines, too costly unless wide and continuing sales could be assured. So we don't get them, nor feel the lack of them. Yet when each World War came we were smart enough quickly to standardize ships, with all their parts, and prefabricate them, as far as transport allowed. So do we always with munitions; standardization originated with *their* production, thousands of years ago.

[220] Two other large but movable civil goods are the automobile and the transport plane. Here again there were no dominant patents to facilitate a needed concentration of production, and in motorcar production there came to be hundreds of auto companies, diversely assembling parts produced by other hundreds of parts manufacturers. At last the slow process of commercial competition has reduced the auto companies to a more efficient few. Henry Ford early achieved a monopoly on the cheap new car, and used it to turn out millions of Model T's at prices as low as $290, with yearly company profits as high as 31% of sales.[237] In the case of transport planes the DC3, an excellent model, achieved not only a national but almost a world monopoly, in the 1930's. But with house trailers we still have 50 establishments building 77,122 a year, worth $2,900 apiece. The standardization of their coupling arrangements has been fairly well at-

[236] Opposition from the building trades would have to be dealt with also.

tained, but not cheap manufacture of the trailer. If there were a basic patent on it, as there was once on the airplane and phonograph, that would be one way to attain quickly centralized production, standardization, and cheapness. Very likely not the *best* way to attain them, but one way, involving a wider monopoly than the present patents give. As for the prefabricated house, our Government's idea of being helpful was to file an antitrust suit against the one firm that had attained sizable production, 25% of the market.

[221] In smaller goods especially, it is possible for standardization to render unified ownership and production unnecessary, particularly if the Federal Government will enforce the standardization, as it has in television. "It's generally agreed that to a large extent the future growth of piggybacking depends on standardization of trailer, flatcars, and tiedown equipment."[238] The use of big freight containers, shifted between rail flatcars, trucks and ships, and refilled near their unloading point, could be much helped by standardization and wider control than today's (¶ 375).

[222] Fifth, *Inventions not assessable upon their beneficiaries*, i.e., which have to be paid for by a party who gets little of the benefit. Such inventions merge on the one side into scientific discoveries, with which they form an enormous group, unable to use patents, or unwilling to. Examples are a surgical procedure or simple apparatus, or a technique for ultrarefined measurement. On the other side this class becomes like ordinary inventions, except that they are more or less for the benefit of other parties than the contriver and/or builder of the invention, who has no good way to charge for his services, however welcomed and important. Examples are smoke and smog prevention devices, all those for obviating pollution of air or waters, or for wholesale eradication of pests or diseases, an automatic headlamp dimming system,[239] which is more for the benefit of the approaching driver than of the one who installs it, and many inventions for American railway freight cars, viz., all that cost money but serve to lighten the weight of the car or otherwise reduce its rolling friction, or its liability to trouble en route. With locomotives and passenger rail cars the case is different—we find in them roller bearings and all manner of improvements, because the same railroad that paid for their building and inventing, uses them throughout their life (or sells them for all they are worth to another line). But freight cars, 44 times more numerous than all in passenger trains, spend about half of their traveling time, and of their loadings and unloadings, on the tracks and at the expense of some other railway or shipper. So the railroads' motive to improve their operating characteristics, aside from durability, is diluted by half. If a freight car develops a hotbox for lack of roller bearings, and stops a whole train, like as not it will occur on the line of another company. There is also the factor of other railroads lacking facilities for servicing roller bearings, a matter of standardization. From these factors, one would think, stems the slow progress made in freight cars, inferior to that of passenger cars, though far more freight cars are built.

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[239] An additional possible need, of universality for one system, is mentioned by Frost, quoting Maclaurin as saying in 1950 that no auto manufacturer had yet done significant work on this much needed invention. But now some devices are on the market, and RCA has been developing one for 5 years. After all, to help the approaching driver may save one's own life. Jos. M. Guilfoyle: The Idea Mills: Industry's scientists shape basic research to commercial ends; *Wall St. Jol.*, Mar. 13, 1957. For Frost see N 221, in his note 17 on p. 7.

[223] It is in our other direction, where the inventions for non-chargeable benefit merge into science, that we find the most extensive nonuse of patenting, partly where this is barred legally or economically, partly where it is rejected as too grasping for the ethics of science. Of course discoveries, new principles, theories and facts, however instrumental and indispensable they may be for invention, are in general legally excluded from the Patent Office (¶ 202). But there are also innumerable scientific inventions that could be patented. Yet if they are made by Government scientists, in such fields as agriculture, food processing, medical research, drugs, crime, or the post office, not to mention war, the scientist or his Government boss either reject a patent, or take one which serves no important purpose, perhaps opened to all, so that we do not count it as part of the "patent system," even if it appear in the patent counts. Likewise in universities, physicians, physicists, chemists, astronomers, biological and other scientists usually hold patenting unethical, or a nuisance to themselves and their confreres, or too commercial an activity for a university, so that they take either no patents, or uncommercial ones (¶ 127). Palmer [160] and Forman [208] think such university and governmental patenting should be encouraged. The present writer thinks that even if so, such patents rarely serve any important purpose, and are essentially not a part of the patent system, which implies the competitive ownership of inventions.

[224] Sixth, *Inventions for Government*, above all for war purposes, including such fields as medicine, insecticides, navigation, shipbuilding, metallurgy, meteorology, atomic energy, rocketry, and aviation, spell either no patents or unimportant ones, even if devised as commercial speculations—as we have said just above, and previously (¶ 127–9). And similarly, with inventions for the Federal Government in other fields than war, chiefly the postal service, agriculture, aviation, its ground services, weather, coast guard, lighthouse, surveying, mapping, printing, engraving, mental and other medicine, testing for quality, safety and standardization, river and harbor works, the NASA with its satellites, and for other activities. Hollerith invented the first electric punch card system for our Census of 1890, when by the way, it came under the patent system, not compulsory license as it would today.

[225] Our State and local governments might enter the invention field for crime prevention, detection, and incarceration, mobile radio, office machines and methods, tamper-proof records, voting machines, educational and recreative devices, agriculture, forestry, fisheries, water and sewage treatment, air pollution, waste disposal, firefighting, aerial photography, and all manner of civil engineering works, especially streets, roads, bridges, and transit systems. But being divided into 50 States and thousands of local jurisdictions, which face problems mostly identical, but have each their separate tax basis, legislatures, political leaders, and separatist traditions, they are each too small to have the resources and market needed for efficient invention without patenting; so they leave origination almost totally to commercial sources and to the Federal Government.[240] If they were minded to science and business, like the companies, they might some-

[240] One exception, explainable by an acutely emergent need largely centered in one jurisdiction containing 5 million well endowed people, is the unequaled research by the Los Angeles County Air Pollution Control District.

times profitably go into invention, and use patents to recoup royalties from the other cities and States that would copy their new ideas. But they are not so minded, and such commercial inventive activities would be labeled socialism, and poorly handled by their political system; so they leave them generally to the more capable and universal Federal Government, and to private industry. Yet many of these activities belong peculiarly to State and local government, e.g., firefighting, sewage treatment, and education.

[226] Cooperative research and invention in the several fields, by associations of all the State governments, and all the cities, counties, engineering districts, and boards of education, would seem particularly appropriate, but has never been done except for a small amount of research, trouble-shooting and especially publication of the good novelties (created by others), through the service of voluntary associations with small dues and budgets. Such are the International City Managers Association, Council of State Governments, American Municipal Association, Government Research Association, American Association of Planning Officials, and various leagues of cities, and associations of county officials in each State. Here progress comes largely by imitation of the occasional successes achieved by small experimenters in local governments and private companies, rather than by well planned attack upon great problems, with outlays proportioned to the national or world need and to the apparent opportunity. The cooperative research and invention which our State and local jurisdictions decline to use to any large extent, but which the commercial companies use somewhat more, has been fostered in Great Britain by governmental subsidy of trade association inventing, and its great expansion will be proposed in ¶ 537.

Summarizing the Field for Patents

[227] The types of invention which patents most often fit are best defined in economic terms of the invention's difficulty, and of the owner's social need for protection against rival producers. One might say that patents are most needed by commercial producers subject to competition, on inventions having a large market outside the Federal Government, and perhaps in foreign countries through foreign patents. And the invention should be a valuable one, not a trifling detail, and difficult, but not so extremely difficult as the fundamental inventions, that will take many years to develop under present lack of assistance.

[228] The more patentable inventions can also be defined by field—they are mechanical, electrical, chemical, or bacteriological, rather than macrobiological, medical, surgical, or in human skills, methods, mental operation, or social organization, though there are patents on complicated and novel apparatus for such human work. The inventions and discoveries for the use of the human mind and body are enormously important and frequent, but they are rarely patented nor patentable apart from remarkable new apparatus for such cybernetic exercise. Examples of such exclusions are a surgical technique, or a new ballroom dance, or a new method of predicting the weather, or solving any scientific problem.

[229] But and always, we should recall that inventions, discoveries, and other work not by itself patentable, may be paid for, and be patented indirectly, through patents on suitable inventions which occur as a joint product with unpatentable work.

Chapter 7

THE BASIC MERITS AND FAULTS OF THE PATENT SYSTEM

[230] Although most of the virtues and shortcomings of the patent system have been earlier noticed, especially in the two previous chapters, it should be worth while to list them all in a new conspectus *ad hoc*, with further discussion of aspects not treated before and not commonly appreciated. Even then we should not finish the subject, but leave that to our later chapter 10, covering remedies suggested.

A. The Economic Justifications Recapitulated

In chapter 5 (¶ 156 ff.) the sound, rational, economic reasons for patents were listed as:

[231] First and chiefly, Encouragement for making useful inventions that might have been not found, or not soon enough, without the prospect of a patent (or some other reward). This purpose and protection covers all the many and great developmental expenses that beset invention, the procuring of capital, etc. The economist Schumpeter said "The introduction of new methods of production and new commodities is hardly conceivable with perfect—and perfectly prompt—competition from the start. And this means that the bulk of what we call economic progress is incompatible with it." [242]

[232] Second, worldwide Publicity for the new ideas, and for such other bits of technology as are described along with the inventor's contributions. But patent publication is years late, and often incomplete and obscure.

[233] Third, the Defensive purpose, for a minor aid in fighting off the attack of someone who would get a patent on the same idea. But there are other, simpler and cheaper ways for an inventive firm to defend itself (¶ 167, 168, and 504).

[234] Fourth, to Prevent Inferior patented inventions from being used in competition with a patented best method. This again is a negative merit of patents, in that they can sometimes be used to remedy an evil which would not exist without them (¶ 169, 170).

[235] Fifth, to Control quality in the product, or a way of doing business, or otherwise to protect the public interest, oftenest with medicines.

[236] Sixth, to Honor the inventors and measure their achievements.

[237] Seventh, to Concentrate Production, for enough of the advantages of large-scale production, according to the nature of the case.

B. Virtues of the Patent System

Patents have, especially for their No. 1 purpose above of encouraging invention, a trio of additional merits (or perhaps defects) closely intertwined: Uniformity, Automatic Valuation, and Postponed Evaluation (¶ 252).

[238] For what good there is in Uniformity, our patent system grants all patents on identical terms, the most trivial improvement alongside the most genial masterstroke, the most ephemeral seated beside a fundamental idea like the voice-operated writing machine, that envisages a whole new industry, which under our present system can be realized only far in the future. Uniform treatment of inventions is sympathetic with our ideals of democracy, equality, and legalism, and with the *laissez-faire* economic philosophy, as we mentioned in the last chapter, under the Premises of the Patent System, Nos. 7 and 8. But it fits the evident needs of differing inventions right badly, and is by no means necessary. Germany grants petty patents, *Gebrauchsmuster*, with short term, low fee, and no examination, for the lowest grade of inventions; some propose this for America;[243] and we formerly allowed extensions of a few worthy patents insufficiently rewarded. To say that all kinds of inventions must be patented on the same terms is rather like saying that an elephant, a goldfish, and an adder must be treated alike, because all three are animals. But it does save a world of immediate trouble, uncertainty, and possible maladministration, to treat all inventions as if their needs were the same. (See below, ¶ 245.)

[239] A certain Automatic Valuation, or adjustment of the amount of the patent reward, to the worth of the invention, is another source and justification for uniformity of patents. The more useful the invention, the greater tends to be its reward, and in the 40% of cases[132] where there is no utilization of the invention there is no reward received (except perhaps under our minor principles 3, 4, and 6). Thus the inventor (including his corporation) is stimulated to go on, perfect his invention and get it into use, a valuable incitement where he has something good, and one not so well provided by prizes or awards, as Ballard points out.[244]

[240] All the merits and demerits of the patent system merely *begin* with the provisions and necessary implications of the patent law. The social effects of all these must be filled out and quantified by conscientious, where possible *statistical* observation of how the law works out in practice, in the average, modal case, in the important exceptional cases, and in all the cases together. Such studies as those of Sanders and Rossman,[132] the Patent, Trade-mark and Copyright Foundation,[245] the Senate series, Kottke,[211] and many others we cite, provide such studies of modern inventions, both those patented and the much greater number which are not. Studies need to be up-to-date, since the economic and technic *milieu* is constantly changing, although the patent law remains almost unchanged. But still there may be some use in pointing out clear implications of the patent law, where these are not clear to some of our readers.

[241] The merit of patents discussed above, their tendency to automatic adjustment of the reward to the value of the invention, with delayed evaluation, after a successful invention has begun to pay off,

is paralleled in our other dozen institutions for the support of invention, by deliberate, personal evaluations of the invention, made ahead of time. Such are most imperfect in the case of Prizes, which are offered when the invention is unmade and therefore not well appraisable. With Awards, granted after an invention has proved itself, it may be better evaluated, but still not so well as by the 17th or later year of a patent. In every case someone, if only the inventor himself, but usually an officer of a government, corporation, university, foundation, or trade association, must evaluate a future invention before it is complete, sometimes before work on it has even started, in order to allot the money and labor necessary to try to create it. Support for invention is far more effective if it comes *now*, while the work is a-doing and the bills are to be met, rather than many years later, and most uncertainly.

[242] Summarizing those three related merits of the patent system, as compared to our other systems for securing inventions—Uniformity, Automatic Adaptation, and Postponed Evaluation—are real merits, but so hedged with counter considerations, that their balance of profit is dubious.

[243] A brave string of adjectives was used by the oldtime philosopher Bentham to garland the patent system.[246] "An exclusive privilege is of all rewards the best proportioned, the most natural, and the least burdensome. . . . [A patent] unites every property which can be wished for in a reward. It is variable, equable, commensurable, characteristic, exemplary, frugal, promotive of perseverance, subservient to compensation, popular, and revocable." And he adds that patents cost nothing, meaning presumably that their charges are collected by producers from consumers without burdening the fisc and government, and that according to the old theory we disposed of (¶ 146, 7), it is impossible that a patentee should charge more than the benefit he confers, because without himself personally we could never have got the invention. Bentham's previous point, that patents keep the assessment, collection, allotment and spending of inventional costs in the hands of private enterprise rather than a government, will appeal to people of *laissez-faire* philosophy, who would minimize government, more than to those who look on government as one of various instrumentalities available for improving the citizens' lot and fostering any kind of good.

C. Basic Faults and Limitations of the Patent System

[244] 1. *The uniform 17-year period* of patents, as well as other shortcomings, make them almost wholly useless for supporting the great, basic, Fundamental Inventions, which under present conditions, with little support from patents or any other source take long—40 years or so—to develop. This subject is so important and neglected that we shall devote to it our next chapter.

[245] Uniformity of patent treatment (¶ 239) for all inventions, big and little, from the supremely difficult ones like a hydrogen-fusion powerplant, to the almost easiest, is not a *necessary* trait of the patent system, unless in the sense that whenever a custom is almost universal, the world over, like gambling, it may be called psychologically necessary; or it may be so bound up in traditional and worldwide culture

as to be almost unchangeable. Few propose to change patent uniformity,[247] except for a few limited choices listed in ¶ 502–4 and 520, especially for an option between a normal patent, and a cheap and quick one unexamined for novelty. But really, if we had a mind for drastic reform, it would be possible to grant patents on as infinitely varied terms as the patent licenses of private industry, or the contracts or concessions drawn up between Government and private industries. Indeed, it would be possible to surpass the flexibility of private industry, in freedom to alter the terms from year to year as conditions changed, as we do in contract renegotiation. But all this would require Government to extend into the patent field more of social thinking, flexibility, competence, and vigor than we are used to there. It would also call for high incorruptibility in the bureaucrats; but this we usually obtain in the Federal civil service, and the record of the Patent Office is remarkably spotless.

[246] 2. *Unadaptability.* The patent system, with its uniform standards of eligibility, fees, methods, and terms of grant, is obliged to give but nugatory, valueless service, or else to refuse patents altogether, not only to fundamental inventions, but to most other kinds of invention and work useful toward it, e.g., scientific research, as explained in the previous chapter. But patents still retain a large suitable field for good work, with limited rivalry from our other institutions.

[247] 3. *Dislocation of inventive effort.* Insofar as patents fail to reward and stimulate most kinds of invention and research, but do reward others, they necessarily tend to direct inventive activity away from those, in favor of these, distorting the natural, economic proportions. Thus science, for all its abundant cultivation, suffers a factor of neglect, and great basic inventions like the voice-operated writing machine, lacking all other means of support, suffer obvious and almost total neglect. But minor improvements and gadgets that could be sold in commercial enterprise by any of many competing firms that might get a valid patent on a good (but minor) invention, are stimulated by the patent system and much cultivated.

[248] 4. *Doubtful remuneration.* The royalties or other rewards for a patent, even to reimburse the expenses of an invention, are most uncertain, a tossup, as well as arriving only years later, if ever, when the invention has come into large enough use, unless another speculator takes over the risk, with a down payment. We know that the percentage of patents worked one time or another has risen to 60%.[132] But inventions are quickly obsoleted, and such working, perhaps only a brief trial, by no means assures any net reward, over and above all the manifold expenses of invention, patenting, perfecting, tooling up, introducing, possible litigation, and interest on the capital thus tied up for years. On the other hand a patent may never be worked, nor even intended for working, yet pay off commercially, through buttressing a monopolist's imposing patent walls, or protecting a different preferred and patented method, or "fencing in" a competitor's line of development, etc. The hazards are many. First the invention made for a patent may turn out ineligible for one; 43% of patents applied

[247] Stedman calls patents standardization with a vengeance, and quotes Hamilton on the varying time needed in different industries. N 215, p. 633 its note 53. The late Sen. Kefauver and the Antitrust and Monopoly Subcommittee would restrict drug patents, to require utility, and CL after 3 years.

for are never issued. Next, three-fourths of those issued and sued on to a judgment are destroyed. We calculated in ¶ 146, that very few of the patenting proposals which get as far as a patent attorney's office, ever eventuate in a defensible patent, indeed four-fifths never get a patent. A patent might be litigated and upheld and still not pay for itself, though it probably would if it were so egregious a patent and invention as to pass all those hurdles that only some much less than 9% of started inventions ever survive. If the patent be *not* sued on and upheld you can hardly know for sure that it had been worth taking out; though if the invention has been worked, and its patent seem strong, and it has been used to threaten would-be infringers who then desisted, one might well infer that this patent rendered returns. In the other cases, probably the majority, the patent probably served no very profitable purpose (¶ 407); for no one needs a patent to practice his own invention. The commercial profitableness of patents is chiefly based on the actuarial value of a few payoff cases, some of which yield great rewards, though probably the majority yield no net profit. Patenting is the most aleatory of all commercial gambles, comparable to buying a ticket in a lottery.[249] Frost says "Any industry position based upon patent rights is most precarious." [250]

[249] If the possible patent payoff were the only reward in prospect to inventors, the patent institution would probably shrink greatly. But there are many other reasons for inventing, and even some other minor motives for patenting. So invention continues its swift expansion (cf. charts 1 and 4), while patents lag, as byproducts, ever more so, of the invention industry. The freelance inventor still depends on them, but to most great corporations they are something of a bonus, a lottery ticket which may, if the invention looks well, be bought at small expense (compared to the total cost of making and introducing the invention), a ticket which will like as not pay some reward, and possibly a bonanza. There is also the gambling instinct in some men, and excessive optimism in many.

[250] From the social view, as contrasted with the above commercial view, the usefulness of patents is sometimes wider, sometimes narrower. For they may repay society though not the patentee. When they lure inventors to do useful contriving, the social gain may be real however vain and frustrated the inventor's hopes, and whether or not he gets a patent. Inventors, at least the old freelance kind, are notorious for overestimating the future value of their own work. Patents may give a real, social value to a pot of gold at the other end of a rainbow.

[251] Another consideration, mentioned before, is that the aleatory character of patents disappears the more of them are amassed together in the portfolio of a great corporation, by the principle that large numbers even out chances. And transferring the burden of risk from the personal inventor to a corporation which salaries him, on condition of his assigning all patents to it, is a great help, not only from the principle of large numbers but because the serious inventors, mostly engineers and chemists, have neither the capacity nor the bent to engage in wild and long-range inventional speculations.

[252] 5. *Delayed remuneration.* This related defect of patents is hardly ameliorated by large numbers, is helped by the stout treasuries of great corporations, but remains perhaps the most serious shortcom-

ing of patents, at least for the small firm or man. For the costs of serious inventing may be immense, including necessarily the costs of development, tooling, and introduction, say a million dollars for a new engine, and many millions for a new airplane or synthetic fiber. And all these costs must be met *now*, with cashable checks, not with shares in a patent lottery, which is to pay off 10–30 years in the future, *maybe* but like as not nothing. Such tickets may be actuarially worth while, but they are hardly legal tender to pay the laboratory expenses; they will not buy the baby a shirt, the poor, naked, helpless baby invention. This is one of three great reasons (the others being war and the socializing trend) why Government inventing has in the last forty years risen to overtop all commercial support (chart 3 and ¶ 431). The Government pays the inventors and their laboratories *now* and certainly, and assumes all the risks and delays, as to whether the invention will ever succeed, to whom it will profit, how much, and how many years it must be waited for. It has been obvious that commercial invention left to itself or to the patent system, would not produce promptly the needed flood of particular military inventions.

[253] 6. *Laying a toll upon innovation* is another fault inherent in the patent system, and very important, yet rarely talked of, hardly perceived apparently, save where the patentee refuses to license.[251] Whenever royalties are charged for the use of a patented invention and perhaps know-how, they are reckoned as an addition to the producer's costs, and hence tend to be added to his sale price, thus reducing the good's sales, in favor of the old art, which is free, or tending immediately to be made so, when the better art appears. As a further device for this end "Restrictions are customarily applied to any product that is produced under a patent," [252] to hold down the quantity produced, keep up the price at which it must be sold, or restrict the territory, or the uses to which the licensee may put it. Such restrictions may be welcomed, as part of a policing of the industry versus the consumers, even when there is only one licensee. "Sometimes they are eager to be restricted," says Edwards.[252]

[254] Patents are intended to encourage, not burden invention. More logical than our present system would be to levy a tax on the use of old methods, and pay the proceeds to the users or the patentee of the improvement.

[255] Where the patentee works the invention himself instead of collecting royalties on it, he is still obliged in greater or less degree to tax the users of the new, to recoup his costs of innovation. He will be especially inclined to do so if he has a cost accountant at his elbow. Cost accountants are hardly economists; they are normative bookkeepers who try to apportion joint costs by fixed rules, somewhat insensible to swiftly fluctuating economic realities spelled by invention and competitive business life. If an invention cost much to make, their rules tell them that that cost should be assessed upon the resultant goods sold. And there should be a further charge, their rules tell them, to cover the unsuccessful attempts. Still less are cost accountants concerned with the national welfare, when it differs from their firm's. It constantly differs anent invention; for the national interest usually asks for more invention rather than less; but to the firm there is a sooner reached profitable limit beyond which it cannot

afford to extend its inventive activity; and in the case of the smallest firms this most profitable extent is usually zero.

[256] A Senate committee recently elicited spectacular testimony on high levies of invention costs upon the novelties produced in pharmaceutical manufacturing and importing. Royalties many times the cost of the drug are often charged, because in this industry the demand is inflexible. Once the physicians have been persuaded to prescribe the new drug, the patient will pay almost any price to get it. Naturally, this supports a particularly avid invention industry, but by multiplying the price and restricting the use of its new drugs.

[257] In short, whether the invention be licensed, or worked by the patentee, the patent system tends powerfully to tax its use, thus favoring its untaxed, obsolescent rivals. This is a great drawback, from which are free most of the dozen rival institutions for the support of invention, viz., all (except in the degree they charge patent royalties) inventing by trade associations, foundations, universities, Government, patent pooling, etc.

[258] 7. *Fostering industrial monopolies* is the fault for which the patent system is oftenest impugned. Since this subject has been covered thoroughly and much better than the present writer could, by many competent authorities in the present series of Senate publications [253] and elsewhere, we shall say no more about it than our few remarks in ¶ 158,9 and 428,9.

[259] 8. *Excessive and insufficient rewards* are corollaries of uncertain reward, as we should expect on mathematical and social principles, in spite of the tendency of patents toward automatic valuation which we discussed (¶ 239). Insufficient rewards, amounting, often as not, to a minus quantity, i.e., the patented invention not repaying all of the many outlays it required, are very familiar. We have just been speaking of them under the fourth and fifth drawbacks, and they are certainly commoner than the excessive rewards, although perhaps not actuarially weightier. Excessive rewards are rare but important, since one big success may make up for many failures, actuarially and through the psychology of the gambler. We may cite as excessive rewards the millions received by the inventors of the rubber-tipped pencil, the copper-toed shoe, the "Selden" motorcar, and the telephone of Bell, who seems to have added little to the simultaneous and previous work of Gray, Reis, and Drawbaugh. (See ftN *9*, p. 13, and *115*, p. 36.)

[260] While excessive and insufficient rewards might possibly balance out in the long run at a proper level, especially to a great corporation having many patents, immortal life and deep purse, still for the small man or firm each reward that is too much or too little offends our sense of justice, and what is more important offends economic principles, especially in that the deficient rewards (usually a net loss, often serious) bankrupt or discourage good men and projects in the smaller scale of industry, that are rendering inventive services even if they have not produced a winner, and that need to be helped, not ruined.

[261] 9. *The costs* of operating the patent system are certainly a drawback to it, since they add up to quite a sum of money and labor, none of which goes directly for inventing, but almost all of it for conferring and protecting the ownership of inventions, and a little for the second and fifth, sixth, and seventh minor purposes of patents.

All the rival institutions for supporting invention save these costs if they dispense with patents (even if they incur some other costs instead), and those others that use patents avoid their costs largely, since they do not struggle much over rights. But of course each system rival to patents involves its own costs.

[262] To enumerate the costs of the patent system, there are first the various Patent Office fees, amounting to at least $60 per patent, $6,863,000 per year, and the running expenses of the Office connected with patents, estimated at $14,430,000 additional to the fees.[257] Then there is the interest cost and running of expenses for the pertinent Patent Office quarters, which we guess at $900,000 per year.[258] Next come the expenses for an attorney, etc., amounting to $620 for a typical simple invention.[259] There are about 5,200 patent attorneys and agents,[259] both free professionals and the corporation-employed. After dropping a fourth of these, on the guess that they are otherwise occupied or retired, let us estimate their bills, or gross income, at $24,000 per active man yearly, for their personal earnings plus their staffs, offices, travel, etc.,[260] on the assumption that they are like the non-salaried general lawyers reporting to a Government questionnaire. This would bring their gross bill to about $94 million.

[263] The patent attorneys draw up and prosecute the patents, sometimes by suits and appeals to force their issue, and in perhaps 2.5% of applications by particularly costly interference proceedings between rival applicants,[207] next by detecting and threatening infringers, and finally by suits against them. These numbered a few more than 731 filed in fiscal 1956,[261] including 642 in the district courts, only 59% as many as in 1940; and there were 76 appeals to the Circuit Courts,[262] and 13 cases entered in the Court of Claims. Juries are seldom used.[263] Patent suits take more time and fighting[264] than any other class of civil suit except antitrust and Taft-Hartley; 4.57 times as many hours as the average civil case, at least among 8 tried and 20 otherwise terminated cases filed in 28 district courts in a 1955 study.[261] Their average time for a case was 11.6 hours, 53% in court and the rest in chambers; but the 8 cases that went to trial, one with a jury, averaged 30 hours, two-thirds of this in court. About 5 hours make a court day, and a separate count[265] by days of the 114 patent cases completed in the district courts shows a modal length of 2 days, but a mean average of about 4.4 days, for a single suit in the lowest court. While only 11.4% of the cases went through with a trial,[263] all the cases in the time study occupied, in court and chambers, 3.64% of these district courts' time.[266] On the assumption, rough but usable, that the same percentage holds in the remaining Federal courts,[267] we get $1,120,000 as the judicial salaries and other court expenses budgeted to the courts and attributable to patent litigation. To this we must add a "guesstimate" of the rental value and operating cost of the

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[263] Of the 680 cases terminated, 3.7% were dismissed for want of prosecution, 0.7% by default judgment, consent judgments before trial were 19.4%, during or after trial 0.6%, consent dismissals 57.9% before trial and 0.6% during or after, and 0.8% were other cases, before coming to the contested judgments: judgment by decision of court before trial 4.7%, after nonjury trial 10.9%, no directed verdicts, judgment by court during jury trial 0.1%, and judgments on jury verdict 0.4%. Only 4.4% of the private patent cases used juries. From the judicial report cited, p. 223.

[264] Mayers cites $25.000 as a typical cost to each party. N 22. A former Comr. indicated a higher cost. Cf. also Petro. ftN 9, his p. 352.

[267] Amounts obligated, omitting the Supreme Court and fees for jurors and commissioners, whence the above 3.64% is reduced to 3.2%. FtN 263, its p. 299.

court buildings budgeted to other agencies of Government, taking the 3.2% as the percentage attributable [267] to patent litigation amongst all other court business; so we estimate [268] $74,000 as the yearly cost for court quarters. Next we must add in the value of the time and office space and assistance of the inventor and his executives and assistants, whenever occupied with getting or defending or getting around a patent, or when being sued for failure to get around it. Perhaps we should estimate this at a quarter of the gross bill of the attorneys, viz., $23,400,000. Finally should be added serious items on which no estimates have been found, the costs for expert witnesses, travel, transcription, etc., not ascribed to the attorney's own office, or gross income.

[264] The grand total of the direct costs of the patent system now adds up to at least $140 million *per annum*, without inclusion of the unestimated items, making $220 per year for each patent nominally in force because issued in the last 17 years, or $3,000 for each patent issued in the 1961 fiscal year. It is quite a price to pay. To be sure, our major items are shaky estimates; (¶ 12) if the reader have better information, let him correct them. And these are only the direct costs; if we were to count in all the indirect costs, mentioned elsewhere in this chapter, and also the benefits, the total would be quite impossible to calculate, and might be greater, or less, than the above estimate of the direct costs alone.

[265] Though quite a price, these direct costs of patenting are probably justified in most cases, *unless* we can envisage a better method, such as we shall offer later, for dealing with that portion of invention, estimated in at about a fifth, which is still motivated by the patent system.

[266] Since patent litigations are particularly protracted and expensive [269] as we have seen,[234] the Science Advisory Board,[270] D. L. Ladd,[271] former Commissioner, and others have protested their cost. Greenawalt [272] cited the case of Carson, a poor inventor who at first lost all cases; then getting the backing of wealth, he won all cases, and $4,000,000; but it cost him 85% of this to get it, and 9 years. Again and again we read protests that patent litigation, and the threat of it, and the necessity of being ready for it if one is to retain control of a good invention, favor the great corporation, and force a small opponent to bankruptcy or to selling his patent on the big fellow's terms. *Fortune* said [234] that a patent suit is one of the most expensive forms of litigation, and that "a big corporation, working from a base containing as many as 10,000 patents, can usually, if it wishes, find a basis on which to pursue almost any competitor. More time, money, and energy have sometimes gone into this kind of warfare than ever went into the original technologic development." "The average time from the grant of the patent to the decision of the court of appeals was 10 years, 7.5 months." [273] MacLaurin, also protesting, says "Nearly 40% of the total patent suits in the [electric] industry on which we could obtain information lasted over 2 years. As an extreme case, on the regenerative circuit Armstrong and De Forest submitted their patent applica-

[269] Although there are no patent suits between automobile companies, GM was involved in 124 with others during 1924–37, costing $2,526,010 (without judgments), although only 18% of them went through to judgment, an average cost of about $20,000 per case. TNEC *Hearings*, N 299, at pp. 365, 700.
An Analysis of Pat. Litigation Stat, staff rept. of the Subcommittee on Pats., etc., of the Senate Committee on the Judiciary, pursuant to S. Res. 240; 1961, 30 pp.

tions in 1913 and 1914; but the final decision on priority of invention was not awarded by the Supreme Court until 1934," reminding one of Dickens' *Bleak House* case. "By the time the De Forest patent was upheld, De Forest had sold it and gone through several bankruptcies and left the radio field, while Armstrong had also sold his patents because he said 'I was in danger of being litigated to death,' " [274]. One patent, No. 1,423,956, figured in 72 suits. Edward Weston, the great inventor of electrical instruments, dynamos, and lamps, finding one of his creations being universally copied, his ruin threatened and his resources insufficient to tackle GE and Westinghouse, "smartly compromised by starting separate suits against his weaker opponents first, picking them off one by one and gradually establishing a body of evidence by which to confound the big fellows later on. . . . Finally he stood on top." [275] Costs in England in chemical suits were said to be the worst in the world in 1929,[276] amounting, for both parties, to £600–1,000 per day. "Counsel who could grasp chemical facts and present them to a judge effectively from a legal point of view were scarce." American patent suit costs have been estimated as usually $25,000 per side or more, the Senate subcommittee reported.[277] "The ironic result is that we create a system that is peculiarly valuable in principle to small concerns and individuals, and then price these very people out of the market by putting the cost of obtaining and enforcing their patents beyond their reach."

[267] The competence of judges trained only in Law, to understand and determine questions of fact on the latest frontiers of chemistry and physics, with the aid only of partisan, mutually contradicting experts, is a principle often attacked, which is taken up in ¶ 510 and in Whinery's study No. 8 of the present series.[503]

[268] The great costs, delays, and uncertainties of patent litigation lead inevitably to several consequences. Three we have mentioned: the declines of patenting and of litigation, and the strengthening of the strong vs. the weak firms. Add of the ruthless vs. the conscientious. The evidence of charts 1 and 4, showing how the ratio of patents to inventive effort and output has steeply declined in the past 80 years, leaves plenty of further room for this factor to operate, if the litigation situation becomes either worse, or more fully realized. We may cite an instance from Weston again, who really enjoyed litigation,[275] and once had 64 suits in court at the same time. He took out 309 patents in all, but mostly gave up patenting after 1886, when 36 years old, because he concluded it used up too much time and money.[278] He depended almost always thereafter on the year or more of head start which secret invention and development allowed him, and on the unrivaled prestige of his company.

[269] Other inevitable consequences of the burden of litigation must include some measure of turning away from invention altogether, or from its more serious fields needing patent protection, in favor of easy, minor improvements, or to inventing for the Government. And some freelance inventors will go to work for a corporation, or sell their patents to them, as Armstrong and De Forest did, or keep their inventions secret for a while, as can easily be done if they be kept unused and the patent delayed from issuance. In any case we can see that the evil of patent litigation is declining, both from the drastic decay of patenting (ch. 3), and from direct observation of litigation.

We have noted in ¶ 263 a 41% decline since 1940, in suits filed, and some longer data in table 2.

[270] 10. *Interfering with the natural flow of economic effort.* Those interferences are infinitely numerous, and probably important in total. Economists know that the working life of a nation is a moving equilibrium like that of a ship, in which every movement of weights within, and every force from without, affects the angles, immersion, speed, etc., of the whole ship. Each economic effect has in turn further effects ramifying *ad infinitum*, but quickly passing the limits for profitable discussion.

[271] We have already mentioned in this chapter several interferences from patents, especially their royalty taxation of novelty by adding to the sales price the cost of making and introducing the invention, thereby discouraging its use and favoring the old way (point 6); the deterrence of inventors without a spare million or two for fighting patent suits, away from difficult, serious inventions that need patent protection (point 3; not to mention from great fundamental ones); a probable net loss from invention for circumvention of a patent (¶ 180,1); and fostering great and ruthless corporations and lasting industrial monopolies (point 7). Interferences needing to be taken up here are first—

[272] 11. *The encouragement of secrecy.* Secrecy is usually thought of as a substitute for patents, i.e., a consequence of their *non*use. But this is a too limited frame of thought, contemplating only commercial inventing, and the alternatives to patent it or not. Such simple commercial secret working is by no means the only alternative to patents. Moreover, it is usually a nonexistent alternative, as we said in ¶ 148 and ¶ 164—it is almost always impossible to *use* an invention of any importance, and keep it long secret. The commonest today of all the substitutes for the patent system is of course invention at government behest. This and almost all the other substitutes eliminate secrecy, or reduce it compared to the patent system. Of course military inventing hides itself from the enemy and the public, because otherwise the profit of the work were lost. But it is not hid much from those Americans who need most to know about it because they are working on related military devices.

[273] Furthermore, a patent is supposed to eliminate secrecy by making it unnecessary; but publication is insured only when and if the patent is granted, and many years may precede this, while the invention is being worked out, and then put through our clogged Patent Office, perhaps with further delay contrived by the attorney, during all of which time the discovery of one's ideas by outsiders might invite costly and perhaps successful interference proceedings, or simply enable free rival working until the patent issues.[279] A bad example is that of the first flyable airplane. For 2 or 3 years after their first flights of December 1903 the Wright brothers discouraged publicity, accepted the world's incredulity and indifference, worked quietly, progressed slowly, and got their patent issued only in May 1906. One of them was quoted as explaining, as to why the world heard little of them for 5 years after their first flight, "We decided that we would be absolutely lost if our patent became known before we had $200,000

to fight with. Our experiences in the courts have indicated that we did not overestimate the money needed." [280]

[274] A yet worse instance is that of Domagk, who in the 1920's made the accidental discovery that a family of azo dyes had bactericidal power. His company, I. G. Farben, clamped on secrecy for 5 years, until they could find something good to patent, Prontozi. Promptly on publication researchers in three other countries not only broke the patent, but perfected better drugs, the sulfa family. From that 5-year delay caused by the competitive invention system, millions of men may have died, and the present writer lay at death's door, with a ruptured appendix and no sulfa drugs, in 1926.[281]

[275] A patent protects only the details which it explicitly claims, or which are not practically usable without the protected elements. It is supposed by law to tell everything needful to work the invention in the best form known to the inventor at the time of application, but this requirement is frequently violated,[282] and does not cover even legally all of know-how.[283] Furthermore, patents are often written as incompletely and obscurely as can get by, as we said before (¶ 164). And in all cases the inventor gets further ideas, both before and after his application, beside those put in the patent. So there is commonly a mass of know-how that is needed to complete a patent; and this is often held more or less secret, and sometimes sold, with perhaps instructors furnished, when a patent is licensed. The latest study [165] of assigned patents finds that know-how was a necessary supplement to half of them.[284] We shall later (¶ 419, 482–4) consider sold know-how as a distinct substitute for the patent system.

[276] Furthermore, the prospect of patenting forbids all publication more than a year before the date of patent application, since that would bar a patent; and to keep on the safe side discourages all publication before the patent's issue and even longer, until all the developments, bearings, useful hints that the inventor or his rivals might derive from the invention, have been worked out and either found of small value or patent applied for on them, as Melman says.[285] Publicity is not always harmful to a new patent interest; it may be helpful; but it always involves dangers too.

[277] We have here to deal with two separate though related institutions: the patent system, and competitive, commercial enterprise. The former certainly combats secrecy when and where patents work; but we see great shortcomings from what it *might* do, particularly through delays. The defects of patents as conveyors of publicity are due not to patents as such, but to delays and to the competitive commercialism back of patents. When and as published, they may be said to reveal much and conceal nothing; but the commercial rivalry back of them may conceal a host of details and scientific knowledge not patented nor patentable. That underlying competitive institution almost inevitably favors secrecy for all its production methods and knowledge, and publicity only where it is selling or buying something of the public. The shortcomings of patent divulgation could be alleviated in various ways to be discussed. The close-holding tendency

[280] Fred C. Kelly in his authorized biography *The Wright Brothers*, 1943, 340 pp., confirms their avoidance of early publicity, but in correspondence doubts the quoted statement, and points out that they sued in 1909, with less than that money, but promptly after incorporating. The quotation is from an editorial in *Outlook* 106: 607, 1914. Their patent was applied for Mar. 23, 1903.

of the greater institution, competition, would seem to be inherent, and reducible only insofar as rivalry is reduced, e.g., through great corporations serving larger shares of the market, or through entry of the more social, less competitive spirit of modern big business leaders, having college educations including the social sciences. It has been claimed that the great, modern corporations use less secrecy than small firms of the older, more competitive type; and American corporations less than foreign ones.[286] GE and Bell laboratories even publish journals to acquaint the world with some of their findings. The secular trend seems to set against secrecy, save for war. If we compare our 17 institutions for the support of invention (¶ 2) we see that their varying dependence on patenting-with-secrecy goes quite hand in hand with their degree of competitive motivation. Our recommendation of an 18th, novel institution in chapter 11 has a principal merit of offering maximum relief from competitive secrecy, while retaining commercial management.

[278] The secrecy innate in commercial competition can be lasting only in processes, chiefly chemical, temporary in products, and is very rarely gross, a complete and long-continued concealment of a really valuable invention. But in its milder forms secrecy is so vastly prevalent as to amount to a major fault of all competitive systems of making and holding inventions. "By and large, the mass of specialized data assembled in the course of industrial research does not become available to anyone except the owners of the laboratory." [287] The obstacle which all secrecy obtrudes, to the rapid adoption and further improvement of all inventions, is too obvious to need more than mention.

[279] The secrecy associated with patenting can be discouraged while retaining patents, (*a*) by putting a premium on prompt application, through abandoning Interferences and granting the patent to the first applicant, as most countries do, unless theft of the idea can be shown; (*b*) by prompter processing in the Patent Office; and (*c*) by preliminary publication of applications, etc. For more definite proposals see ¶ 91–7.

[280] In some degree the deeper secrecy—or merely more reticence—of commercial, compared to nonprofit inventing, is due to a different attitude and kind of men, says Kottke, the thoughtful student of electrical inventing.[288] Industrial scientists are not writing men, they will often *tell* things they have not published; but university professors, and commonly government scientists, are obliged to write for publication, and professors are writing and talking men.

[281] 12. *The obstruction* in a patent, to improvement of the basic idea by others, is a notable drawback, although there are ways to get around it; it is an important shortcoming because it is so vastly frequent as to be the normal course in competitive inventing within the same country; its remedies are not automatic, and are often difficult. What constantly happens in commercial invention is that A makes an invention; then B, a competitor, works out an improved variety of it, which he may patent or not; then C, perhaps, and even D and E,

[286] Vernon, comparing American with British trade secrecy, finds more in Britain, and thinks this due to more cartelism there, and more competition here. Acknowledging the paradox of such causation, he does not consider the other reasons which might account for the fact, such as the larger scale of American manufacturing, and the more social education of our engineers and capitalists. Our N 203, esp. his pp. 19–21.

devise further improvements on A's art. But none of the later comers, B–E, can practice their improvements unless A, the basic patentee, can be persuaded by money or otherwise to sell his patent or to grant them licenses to compete with him, and with each other. Their alternative of waiting perhaps 17 years or more for the basic patent to run out, is a very poor alternative, from either the economic or the business point of view. On his part the basic patentee cannot practice his invention *well* without the improvements if patented, very likely cannot afford to practice it at all, and has no way to force a license or sale from the improvers. There results on *impasse*, which the parties seek to untie by any various methods. One or both rival firms may pay for a license on the other's patent, or buy it, or buy control of the firm. Or, especially where the parties are several, they may make a general agreement to cross-license each other on all or a field of patents and know-how, present and perhaps future too, with or without royalties, creating a patent pool.

[282] But with all these remedies, constantly used, none is easy to apply, because they all require the sale or barter of things on which there is no market price. In each case the license (or the wider privilege bought) is worth more to the buyer than the seller loses in selling; so there is a range of indeterminacy between the least the seller would take and the most the buyer would give, a no-man's land to be struggled over, and won in larger or smaller part, by bargaining skill, bluff, lying, and financial power to threaten patent litigation or other penalties. It is hard to strike a bargain where there is no market price for guide, no other way to estimate the values to each party; the parties are perhaps habitual rivals and foes, and each can hope to win more (with luck), if it fights harder or holds out longer.

[283] A grave result of these difficulties is that all potential inventors confronting a basic patentee are motivated to resign the field to him, and not even try to improve *his* invention. For any attempt to use an improvement, patented or not, is likely to plunge the improver into an infringement suit, perhaps based on a dozen patents, not one, if the basic patentee have a thick portfolio of them tying up a whole industry, as did the shoe machinery trust until it was recently smitten by Compulsory License. If instead of fighting they try to strike a bargain, they face all the difficulties of agreement cited above, plus in the monopsony case an inferiority of bargaining power. Thus arises a serious restriction of the field for inventors of all but one corporation or cross-licensing pool, and an accentuation and perpetuation of monopoly, when it comes about that all the improvements and their patents are in the same hands, enabling indefinite perpetuation of an industrial monopoly.

[284] We shall speak again of these difficulties, when treating of patent pooling, and compulsory license, by which nowadays courts in the antitrust cases often set aside the patent system and throw open long strings of patents to compulsory licensing, or even to free use (ch. 10, sec. 13, 14). Some foreign countries attempt to deal with the problem of mutually blocking patents by special provisions in their law, e.g., for compulsory mutual license.

[285] 13. *Invalid and improper patents.* A patent attorney, Eyre, wrote "Most of our patents are either not based on any real invention, or are worthless because the invention is improperly described or

claimed."[289] For proving the extent of these faults we might merely refer back to our table 2, which shows that about three-fourths of the patents sued on to a judgment are destroyed by the courts, especially when appealed. The true percent of invalid or uninfringed patents is a mystery, and might be higher or lower, since only the doubtful, borderline cases, as a rule are sued on. Most who have taken a license under a bogus patent are content to share the monopoly, proper or not, or they are debarred from later denouncing the patent, by having signed a frequently inserted clause promising not to contest it. In the common case of "package licensing" they become thus estopped from impugning *any* of the licensor's patents, though they are the people best qualified to do so.[215] Such a license may be forced on a weaker firm by threat of an infringement suit, or during a trial the alleged infringer may be persuaded by good enough terms to capitulate and either lose the suit or end it by an agreement. We recall the statistics (¶ 263) [253] showing only 16% of patent cases are pushed through to a contested judgment by judge or jury. Such a case was very likely the great one of the Bell interests against Western Union.[290] These won a 4–3 Supreme Court decision in 1888, despite many signs of fraud and error,[291] and in the end agreed to pay Western Union 20% of the receipts from all telephone licenses, and to keep out of the telegraph business.[292] A long string of patents, however weak some of them might be ascertained to be, used to be a great defense for an industrial monopoly against weaker competitors,[297] who could find themselves sued no matter what they did in the monopoly's field. Such weak patents have been dubbed the "scarecrow" type, and have been likened by a chess-player to a serried line of pawns, individually weak but together an impregnable barrier. Recent antitrust decisions, forcing license of whole portfolios of patents, must have considerably

[291] Even the otherwise immaculate Patent Office was perhaps involved, since it had pushed through Bell's patent in the extraordinary short time of 3 weeks despite the interference of Gray's caveat on the same invention, filed 5 hours later. (Bell knew something of Gray's work, and was later charged by the Government with adding to his own application elements improperly shown him from Gray's caveat.) What was most extraordinary was that the majority four Supreme Court justices brushed aside all the prior work of Bourseul, Reis, Gray, and especially Danl. Drawbaugh. Leibtag, N 293, Meucci, N 294, Cammack, N 295, and McDonough[296] have been reported as inventing telephones also. Drawbaugh had an electric telephone working as early as 1867, according to a whole village full of witnessss (126 U.S. 331ff., esp. 339); yet chiefly because (like Bell) he was a man of limited though some electrical learning, and because he had not pushed his invention till Bell did, 4 of the judges brushed aside the unanimous testimony of 70–200 witnesses, an extraordinary procedure, while Justices Field, Bradley, and Harlan would not. Drawbaugh was an ingenious, selfless, and hen-pecked man. His village witnesses had "regarded the matter as more one of curiosity than of public importance." So did Bell's wider public. For the first year after exhibiting his telephone at the Exposition of 1876 Bell received little but derision from it, he despaired of it, and the 2-vol. report of the Exposition made no mention of it. Elisha Gray "left this statement among the papers found after his death: 'The history of the telephone will never be fully written. It is partly hidden away in 20,000 or 30,000 words of testimony and partly lying on the hearts and consciences of a few whose lips are sealed—some in death and others by a golden clasp whose grip is even tighter.'" (Quoted by Petro, p. 367, 8, ftN 9 from MacMeal; *Story of Indep. Telephony*, 1934, p. 11.) Further skulduggery with Dolbear, another telephone inventor and historian, was charged by the Government in a later suit, which was finally dropped without conclusion when most of the patents had expired. Cf. Petro, *op. cit.*, p. 371, etc. Senate *Hearing*, N 329, p. 32; & Hamilton, N 207, his pp. 87–90.

[292] C. D. Edwards says "Even conflict between the claims of different applicants need be no serious obstacle to the development of a patent monopoly", since the Pat. Office will grant a patent to either one if they compose their differences and one withdraws. Again, "Large and small competitors alike may be willing to recognize the validity of a patent as an instrument through which prices can be fixed and other monopoly restrictions can be imposed. In consequence, invalid patents may remain unchallenged. That this is so is attested upon occasion by a court decision that nullifies a patent after years of use. Current examples are the tetracycline case (Amer. Cyanamid), Senator Kefauver's proposal for filing interference settlement agreements, which with modifications has passed the House, the Precision Instrument case, Hazel-Atlas case, etc. Businessmen and lawyers habitually classify patents as strong and weak. Edwards, N 252, its pp. 220–2. Cf. also Senate *Hearings*, N 329.

weakened this particular misuse of patents. Some companies, despite court disfavor, refuse to license single patents, demanding package deals. Levinstein said "To remove the mass of bogus, bluff, blocking, paper patents, valueless but with a menace grinning through the paper mask, would be a wonderful relief to small firms." [298, 252]

[286] *Fencing* patents we prefer to define as patents designed to "fence in" a competitor's natural lines of development, so that he will be blocked or hampered in improving his methods. Blocking patents might be a better term. Probably a rare abuse, it was still charged and punished against the Hartford-Empire bottle trust in 1938.[299] Such fencing patents, usually economically indefensible, merge indistinguishably into the partly or wholly justifiable defensive patents discussed in ¶170, covering inventions the patentee is not using, but might wish to later, or which no one ought to use, because they are inferior methods.

[287] Indeed, almost every type of patent shades into each other type, because the whole subject of inventions and patents is most nebulous. All we can do by way of categorizing it is to point to groups or areas especially well denoted by our used adjective. With definitions so vague and overlapping, of course all statistics are impossible.

[288] Our next group of adjectival types of Improper Patents are some particularly near each other, which have been called the "dragnet," "umbrella," "shotgun," "forestalling," and "nuisance-value" patents. By these we imply a "half-baked" invention, not really operative and practical, but near enough to it to get by the Patent Office and perhaps the courts, on which a nimble fellow or firm applies for a patent as soon as some development, perhaps a scientific discovery, or his own work, indicates it might someday provide, after great efforts, the basis for a practical and important invention. Kahn [224] defines a "dragnet" patent as one to sweep up interferences and later developments. I.e., it will enable a fight with any other earlier or later rival applicant whose patent is not yet granted; and the application, whose acceptance will be carefully delayed, may perhaps be amended to take in later developments by others or himself, by asserted correction, despite the law's attempt to bar this. Hamilton calls a "trap" patent one that forces disclosures by others, which the trapper will then claim.[300]

[289] A "forestalling," "scarecrow," "shotgun," or "umbrella" patent would lack these particular elements of fraud, yet be still a patent on what is not yet a usable invention, but which may contain disclosures of value in the big task of making the invention practical. The most notorious example of a "forestalling" patent was Selden's on the gasoline automobile, skillfully kept in the Patent Office for 17 years by its patent lawyer contriver, until the new auto industry had grown ripe for plucking. There had been steam automobiles for a century, and the world had no need of Selden to tell it that a gasoline engine with clutch, etc., could be substituted for a steam engine; the world went ahead on the same unaware of his application in ambush. Probably such an easy substitution of engines would not be patentable nor upheld today, as Frost says; but this famous patent of 1895 stuck until a court struck it down by bad law in 1911.[301] It had by accident great and probably beneficent effects that are still with us, in the

creation of patent comity within the automotive industry (except that Henry Ford fought and beat the Selden patent).

[290] All this is not to deny that a "forestalling" patent ultimately registers in distributed print, and may really contribute, new ideas of possibly great future, which merit some kind of reward.

[291] Our last class of abusive patents, probably decreasing and not common, is the "nuisance-value" type, again overlapping those just discussed. The name implies that either the invention or its patent is of little value intrinsically, but embodies some threat, at least of an infringement suit. Such patents have been taken out in some numbers both by isolated inventors, anxious to get some money from a corporation legitimately or not, and by corporations seeking not to sell the patent, but to trade it for a license on others they want, from a rival corporation or a patent pool.[302]

Why Are So Many Bogus Patents Granted?

[292] Having shown in preceding section 13 that many abusive patents are granted, largely of no validity yet of some economic effect, and having shown in ¶ 40 that three-fourths of all patents judged by a court are destroyed and having guessed that about the same 3:1 majority of all granted would be found bogus if they were sued on, we naturally ask *how and why* the Patent Office issues a product found spurious or incapable 3 times out of 4 tests, and what could be done to improve its work.

[293] The usual reasons for the inefficiences that crop up in government do not apply. Politics, corruption, lack of education, indifference to the welfare of clients, laziness, wastefulness—from all these common vices and bad influences the Patent Office is singularly free, a veritable model to all the rest of our Federal and especially to our State and local bureaucracies, and perhaps to all the world. Politics seems not to touch the Office (unless in the choice of Commissioner) and the examiners are mostly young men with professional training in engineering or chemistry, who are also studying patent law and preparing to become patent attorneys, or in some cases to remain and advance in the Patent Office. Their average experience in this peculiar and most difficult business is perhaps 6 years. So whence chiefly derives the defectiveness of their output?

[294] It goes back to the very basis and principles of the Patent Office. This is an institution established, planned, and adapted to grant patents, not refuse them. In the Latin and the unindustrial countries the law says that practically every patent applied for shall be granted without examination for priority, "*sans garantie du gouvernement*" leaving the question of validity to be settled by the courts, in the few patents that will ever be sued on. The American system is somewhat similar; but we first make some effort to determine novelty and legality, enough so that 48% of the applications are dropped, then issue a patent which the courts are supposed to consider as *prima facie* valid, but which these receive with scant respect and commonly destroy.

[295] For proof we always want statistics; fortunately very pertinent ones are available.[303] The 75,495 paid applications of fiscal 1958 were handled by about 1,053 examiner assistants and higher ranks, making 71 cases per man-year, and 24 hours for the average applica-

tion,[304] to keep up with the influx, without making much progress on the backlog of 207,000 applications awaiting decision. In addition the examiners managed to do some other necessary work, on much needed and postponed reclassification of patents, study of the industry and literature in each man's field, the court decisions, and improvement of procedure. Three days is no great time for reading, understanding, searching the prior art, writing back objections, reconsidering, and granting or refusing an average application. Some would take much less time, some much more. In former years, when the extant literature was far less, the output per examiner was higher, 3.2-fold more in 1915.[303] An earlier writer noted that an examiner was expected to turn out 25–30 actions a week; [305] another that he was judged more by the number of his actions than by their quality.[306] A corporation's counsel said they expected no more than half a day's time for a Patent Office action, but they would spend 4 or 5 days searching an average case themselves, and 10–20 days on litigated patents.[307] The working problems of the Patent Office have been thoroughly examined in Geniesse's Study 29.[308] On each application the examiner must supposedly search out all pertinent parts of the 8 million American and foreign patents on file, plus the whole libraries of technical literature, in numerous languages, and cover all practice known but unpublished, then make sound judgments on each claim, numbering dozens perhaps in one application, and on every other word and drawn element of it. The wonder is that he can do as well as he does, and that courts pretty well uphold him on the significance of the prior art which he did find and cite in the file wrapper,[309] and that the Office finally grants only 52% of the applications. Dissatisfied inventors can file several appeals to force issue of a patent, which are answered by higher examiners or even the courts. In all of these the first decision the applicant wins gives him his patent; the public has no appeal. And doubts are to be resolved in favor of the applicant.

[296] If this is a good system of law, we ought to have more of it. Every patent case is essentially a lawsuit, the *Inventor* v. *People of the U.S.*, in which the inventor demands that a 17-year monopoly be granted him, in return for claimed services. How would it be if in all civil suits the defendant were limited to an average 24 man-hours for the whole preparation and pleading of his case, while the complainant could use all the time, talent, and appeals his money could buy?

[297] With our patents being granted under these rules, is it any wonder that when some are sued on to a conclusion by a *regular* court, with its great effort and fair success at being just to both sides, half the time the patent is found unwarranted? (In half the remainder it is held insufficient to cover the art whose monopoly was attempted. This last impugns not the Patent Office but the patent system, being a waste.)

[298] Frost says "We do not know what the patent mortality in the courts will be when the Patent Office is current in its work, the classification problem is overcome, and the workload of the examiners is reduced from its present high level." [310]

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[309] Federico finds that in 34/40 cases of an invalidated pat., material not cited by the Pat. Office was referred to by the court. Ladd, N 271, p. 357, n. 15. Frost, N 221, pp. 57 and 58.

[299] To this confession that a cure for patent invalidity cannot be guaranteed, the present writer would add his conviction that while there could be some amelioration, cure is quite impossible under anything like the present laws, fees, and appropriations, which give all advantages to the applicant. One might even say that since the present system produces patents about 58% invalid and 18% not infringed,[311] and we cannot hope much to improve this, it is not so very different from the "registration system" of France and the less industrial countries, which grant patents automatically on application, except that ours costs much more at the start, and delays patents.

[300] Perhaps the best solution were a combination of the registration and the examination systems, such as Zangwill proposes and the Netherlands plans doing (¶ 502). Provisional patents would be issued at once on application, but would lapse after a few years, say seven, unless, at any time sooner, anyone paid a sizable fee for a "thorough" search. This would be conducted by an international office, and would produce shortly either a positive patent or a rejection. Preferably also, this patent be good in Canada, the Common Market and other countries of the Western alliance, not just in one. The main treatment of our recommendations anent patents is left to our 10th chapter (¶ 485–522).[300]

[301] 14. *Delayed grant.* This shortcoming of American patents is one oftenest complained about, because it is a conspicuous departure from our normal and commonsense rule that when a service is asked of Government, it should be granted or refused at once, not years later. To be sure, our whole legal system, except for arrestees watched over by *habeas corpus*, is full of delays; but this is an *obiter dictum*, not an excuse. The average patent granted today spends more than three years in the Patent Office.[312] The Office has long been pleading for more men, higher salaries to retain the experienced, and higher fees to pay for them, and did obtain some help in fiscal 1956, resulting in a 55% greater rate of disposal than the previous year, and a reduction of the backlog pending by 4,300, to 217,000, (201,000 in 1961). The goal is stated as a backlog of 100,000, "at which the work of the Patent Office could be maintained in substantially current condition", former Commissioner Watson reported. But that would be about twice the annual grants, wherefore it would still take about 2 years to grant the average successful patent, although the Patent Office worked on it only an average three days. Mechanized searching, and reclassification of past patents, are hopes for future speeding up and higher quality, if funds will be provided [121] (¶ 498–505).

[302] A large part of the delay is from tardy replies by the applicant, or by his deliberate contrivance, in order to postpone the end of the patent,[313] or to keep his idea secret, or to involve rivals in interference proceedings, as was said anent "dragnet" patents (¶ 288). Something has been done of late to require quicker replies by the applicant.[314] So a long proposed and probably excellent reform would be the Twenty Year Law, by which a patent would be limited to 20 years from the date of application, or 17 from date of grant, whichever term were shorter, unless the Office had been responsible for the delay (¶ 499).

[303] The harm in dilatory granting, which in a number of patents has reached 10, 20, or even more years, lies in the chance of the above indicated abuses, delay in public information, leading to useless duplicated research, a probably too long term for the monopoly, and the occasional injury of competitors who, perhaps innocently duplicating the invention (¶ 146), unaware of the secret patent application or uncertain it will be granted, have started exploitations of the idea, which may suddenly lie at a strange patentee's mercy. Some patent applicants advertise "Patent Pending" to warn off competitors; but this has no legal effect, and other patentees would rather catch competitors by a delayed-patent ambush, like Selden (¶ 289).

[304] 15. *The suppression of inventions* by use of patents is a charge ever and again laid against the patent system, but one which must for the most part be rejected. We have already listed as the 4th economic justification of patents (¶ 169, 170, 234) that they enable keeping an inferior method from being used, when the patent is still in force and happens to be owned by a current user of a better method. To be sure, this small merit is only that a patent may sometimes serve to remedy an evil which would not exist but for patents.

[305] But as to whether patents are sometimes used *improperly*, to suppress inventions which are good and so good that they ought to be used more now, despite any costs of thereby obsoleted capital equipment and personal skills, let us try the case first by the medieval method of oath-helpers, and then by reasoning. Our oath-helpers shall present not only the honest belief of distinguished men, but their knowledge as experts on invention, who should know better than others if this evil exists.

[306] Edison,[315] Jewett,[315] Waldemar Kaempffert, Gerard Swope,[316] F. P. Fish,[315] and various Commissioners of Patents [317] never knew of a case. The American Chemical Society asked its thousands of members to report any cases, and none were reported. The Oldfield Hearings on Compulsory License in 1912 heard 60 witnesses in 27 public hearings, but none of them claimed a case, although compulsory license is the obvious remedy for suppression.[315] Meinhardt in England doubts it.[318] In our present Senate series Frost calls the suppressed patent a myth,[319] and Bush calls it very rare but well to provide against.[320]

[307] Now for the reasons, first why the notorious case of the improperly suppressed patent must be mostly a myth, and then why the myth arises and persists.

[308] To patent an invention is to publish it worldwide, at least when the patent issues and insofar as the legal requirement of clear description is complied with. It cannot be patented in all countries—they are too numerous and differing in requirements and attractions. So the patented invention becomes known, and must be uncontrolled by patent in some countries. It will presumably be practiced in some of these, if very good and important, and by our hypothesis is forbidden to be made in or imported into our own land. But that would raise a scandal we would hear about. Say the Spaniards and Norwegians are enjoying a fine new electric light; but it is not allowed in America. If transportable, some would be smuggled into America despite the customs barrier; then the patentee must prosecute them, or see the scandal grow. Also every patent expires, in 17 years, where-

upon we should see a sudden burst of manufacture or importation of the invention in America, unless this valuable invention had been already obsoleted. The fact that we never, never hear of such scandalous cases, proves that they do not occur. And this in turn proves that gross suppression of inventions by patents does not occur, since if it did, the above phenomena would be almost inevitable consequences.

[309] When respected scientists, like Merton,[38] Stern,[321] and Vaughan,[322] cite inventions suppressed, or a technologist says he knows of a forbidden razor that needs no sharpening nor replacement, it sounds convincing and disturbing. But when we reread their lists 23 and 20 years later, and find those inventions not yet in use, though their patents must long ago have run out, it is evident that the writers had been deceived.

[310] If improperly suppressed patents are mostly a myth, why do we hear of them so often? Every inventor believes *too much* in his own invention, and may be ready to cry from the housetops about the skullduggery or the folly of those who failed to use it, after getting it from him. And next there are plenty of people to repeat the scandalous and anticapitalist or antigovernment story, and pass it on from print to print.

[311] Perhaps the story is "adorned with corroborative detail, intended to give verisimilitude", like the $119,000 Stern said the Bell company paid for 9 Irwin patents, which they then did not use.[321] The trouble is there are so many reasons why a particular invention ought not to be used, that an outsider cannot hope to appraise the whole situation aright, and the insiders do not always do so. How well the invention can be developed to work, how prices and other circumstances change from year to year, what standardizations would be interfered with, what rival inventions are available from time to time, are questions difficult for the enterpriser to assess in the present, and next to impossible for an outsider to know for the remoter past or for the future. Yet without a true, complete answer to all those inquiries we cannot say whether a patented invention was wrongly, uneconomically suppressed.

[312] One good reason for nonuse of inventions is, paradoxically, rapid progress of invention. A familiar example is the introduction of television, long delayed in America till 1947, though earlier in England, and practiced experimentally for half a century or so, and latterly for 5 or 10 years quite good enough to be worth using. It was held back not by scheming patent owners, but by the Federal Communications Commission with the inventing corporations' consent, partly because improvements were by then fast appearing, with the smell of huge early profits in the nostrils of the ready radio industry, and it was to the interest of all that the form to be adopted, standardized, and embodied in billions worth of manufacturers', broadcasters', and receivers' equipment, should be a thoroughly satisfactory form and likely to last (rejecting all incompatible improvements) for many years. The same history of delay justified by prospective progress, was repeated with color television, and must have accounted, justifiably, for countless other rejections or postponements of inventions good in themselves, the best yet, inherently worth adopting despite all costs of change, yet rightly rejected or postponed in the interest of some likely *future* better standardization and investment.

[313] Still commoner is the good invention rejected because incompatible with a past standardization and investment in equipment for making or using the old. Such rejections are usually not capitalist inertia and exploitation, but sound economics, so long as the enterpriser is defending his capital goods, production know-how and his workmen's skills, jobs, and homes.[323] For such capital is part of the Nation's. These principles could hold even if he is refusing to license others to use the patent he is not working himself, provided he is sufficiently supplying the market in some other way. But if he is defending a mere custom that needs changing (¶ 215), or guarding his established goodwill and advertising against an upsetting invention, he is wrong by economics, because those interests are of value only to him, not to the Nation.

[314] However, it is very easy for inertia, or say a prejudice for the old way, to lead to wrong evaluations of the new and the old and the costs of change. Especially is this true with workingmen, who with deficient savings and education envisage with horror the loss of their job, skill and trade through some labor-saving invention, and often fight against it. And indeed they have some sound motives too. It is both unfair and uneconomic that so much of the cost of technic change should be thrust upon men of so little capital and mental flexibility, especially old, skilled workmen, who can recoup only a tiny part of their losses from the invention's benefits, large in total but tiny per capita, which redound to the whole population, and to the innovating enterpriser. We should have more ways, such as severance benefits, retraining and relocation, so that all of us who receive the benefit of an invention should relieve the suffering of those whom the new way smites, just as when we drive a superhighway through fields and homes, we recompense the dispossessed. Enforced high *severance pay*, as in some countries attacking capitalism, is not the answer, for it penalizes both capital and the introduction of labor-displacing inventions.

[315] Refusal to license a patent was avowed by only 12 out of 528 holders of current patents not currently worked, among respondents to Sanders' questionnaire.[324] Three of these had licensed in the past, and as to patents in current use, only 13% would not license; in all, 6%. Recent court orders for wholesale licensing or practical annulment doubtless kept down the number avowing refusal to license.

[316] After all our attack on the "myth" of improperly suppressed inventions, we must now turn and say that we think such an evil does exist, and abundantly, in milder, temporary, or in very rare forms. It is not in the nature of capitalism, nor of government administration, to be infallibly right, nor always absolutely consistent with the public, not personal interest. Even the communist Russian system, with rigid central control and no effective patents, found advisable special commissions to see that approved inventions actually got adopted, despite inertia and private interests.[325] In a monopolistic corner of our own economy it was charged by the Canadian Government, as Vernon says,[326] and by the U.S.,[327] and many people, that the introduction of fluorescent lighting in this country was slowed up by GE and Westinghouse, through control of patents, lest its efficiency cut too drastically the demand for current.

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[323] He cites a 1953 source, but adds that the GE patents were being defied, and also more abundantly worked of late by the owners. Vernon: N 203, its pp. 21 and 22.

[317] The great fundamental invention of the *telegraphone* affords another probable instance. Suggested in 1888,[328] and independently devised by Poulsen in 1898,[329] it has come into extensive use in America only since 1935, in the form of *tape recording*, for which a great and varied future opens out.[329] Its use was begun in 1903, and though it lacked the electron tube to give it volume, there were a number of good functions for it. But it soon fell into the hands of a certain C. D. Rood, who proceeded to smother it and wreck its $5 million company in ways most varied and effective, so that only a few machines ever got into use, some of them sabotaged. The truth finally came out in an 8-month stockholders' suit followed by a hearing before the Senate Committee on Patents in 1932; but by that time the company was bankrupt and its idea smothered.[330] Why should Rood do such a thing? Apparently because the invention could compete with the dictaphone, and could record telephone conversations. Rood was a friend of Edison (dictaphones), and showed this, and had connections with the telephone company, though he denied them. The New York telephone manager had said that one-third of all phone conversations were illicit in some way, if only employees phoning on private affairs, or people making promises they would not keep. So much business was endangered. We know how long their prohibition of telephone recording lasted, till 1948. Yet the clear recordings of the telegraphone can also be very useful to the telephone company, and the company helped develop the invention after 1930.

[318] It appears likely that often patented inventions which are good, but not very good, are kept out of use not by choice of the patentee, but through his incapacity—his lack of funds, connections, business ability, or whatever is needful in that particular juncture. If the invention were *very* good he would probably find a buyer or the requisite elements for exploitation; but there are great difficulties, and therefore with inventions not egregious there will be many failures. Supporting statistics are supplied by the recent careful studies of Sanders and his associates.[331] They found that among the 68% of current patents not currently being worked, a reason given for the failure to use, by the one-third responding of the 35% of inventors who had not assigned their patent, was shortage or lack of venture capital in 28% of these cases, and "neglect to exploit it" in 27%. But among the respondents on the 65% of patents assigned, the assignee of the 70% of these not currently worked, gave each of the above explanations only 1% of the time. While we should much distrust these explanations by the disappointed nonassigning inventors, it is apparent that their personal incapacities were responsible for a number of patents going unworked.

[319] Summarizing point 15, the charge that patents are used to keep good inventions out of use, we have shown that in its gross form this charge is essentially a myth, but that uneconomic temporary or only mildly unjustifiable exclusions are probably a large evil in the aggregate, although there are only one or two severe cases known. But most of this evil cannot be blamed on the patent system. It occurs

[329] The idea is of recording sound (and now anything electrical) with high fidelity by magnetizing sections of a wire, now commonly replaced by a disk or tape. Rood, getting control in 1908, stifled publicity, but sold machines (later denying it) to the Germans, who used them with wireless most effectively to sink our ships, while he held up our own Navy's order. A court referee was also compromised and resigned. N 328.

with unpatented inventions too, and is mostly due to human inertia, ignorance, selfishness, lack of capital to make a shift, and lack of social organization to facilitate change. In the case of skilled workingmen particularly, they may have sound economic as well as human motives for resisting an invention that would rob them of their job, rank and home, and reduce them to laborers without a trade, nor the youth to learn one.

[320] 16. *Rewarding the promoter rather than the inventor* has been often called a fault of the patent system. For all its rewards go directly to the patentee, which is usually a corporation that hired the inventor or bought his patent, and which usually owes him nothing further once the bargain has been struck. Most often he contracts in advance with his firm or government body to assign to it all patents he may get from inventions made in consequence of his employment, simply trusting his employer to reward him sufficiently, by salary raises, etc., if his work be good. By the principles of economics this should work out correctly in this highly competitive employment field, the employee being a very capable and informed person, with some money in the bank and a knowledge of possible openings for him elsewhere. Of course he may hit on an idea worth millions, but that is essentially a product of luck and of cooperative, joint assembly of ideas recently made ready, and as shown in our parable of the garage carpenter (¶ 151), he is sufficiently rewarded by a salary suitable according to the market, for his type of proved or apparent ability. The inventors are usually satisfied with the system, often supplemented by a nominal bonus for each patent, they have no union demanding higher pay, let alone to own their patents, and as one of them said, "Here you can make a hundred mistakes, and the company will pay for them all. But if you make one big success, you're in." Cf. our discussion in ¶ 153–5.[192]

[321] The *freelance inventor* and the occasional employed one who yet retains his patent rights, is usually in a similar situation to the one who sold his birthright for the juicy and ever replenished mess of pottage—he has not the capital, nor the organization of diverse competencies, manufacturing facilities, and sales outlets, nor the talent nor taste for life as an enterpriser. He will in almost all cases sell his patent, or lease it for royalties, and be glad to be more or less rid of it. His importance we shall discuss later (¶396–411 and 458). But if for some exceptional or odd reason, he wishes to play capitalist, he can try it. We conclude that our 16th point, patents' alleged fault of rewarding the promoter rather than the inventor, is much more a virtue than a fault. It is an indispensable means for reconciling the Renascence patent system to modern capitalism, and obtaining the cooperation of 3 very diverse types of men—the technologist inventor, the manager, and the capitalist or the government official.

[322] 17. *The antiquity of the patent system.* Ancientness is a merit where sentiment is concerned, as in religion and nationalism; elsewhere it is ambivalent, of uncertain balance between good and bad. It is a recommendation insofar as it suggests that an institution which has satisfied men's need for so long, should be a good one, *provided those needs have not altered*, as human nature, e.g., is usually little changed through the years. But if the needs, or the surrounding situation, *have* been changing, antiquity is suspect, as prob-

ably needing a course of sprouts. We told in ¶ 35–7ff. how the patent system of 1474 was an ill-adapted and essentially unsuccessful institution for its first two or three centuries; then flourished for a century or two in the age of small, entrepreneur capitalists, of *laissez-faire*, and invention by rather specialized technologist inventors, not much guided by science, nor ever organized in laboratories. But since 1885 in America (chart 1) and elsewhere the patent system has fallen into a steep and profound decline relative to inventing, in this new age of laboratories and science, big business, big government and big wars. Perhaps patents are not so well adapted to all these, as to the small capitalism and elementary science of the previous age.

[323] Reviewing this chapter 7, on the Basic Merits and Faults of the Patent System, we conclude that its various merits are still cogent, but for a declining proportion of invention. Its defects however are ever more felt, as the natures of invention, business, and Government change—the defects of uniformity, unadaptability, dislocations of inventive and economic effort, doubtful and delayed remuneration, *penalization of novelty*, fostering industrial monopoly, excessive and insufficient rewards, the direct costs of operating the patent system, encouragement more than obviation of secrecy, the mutual obstruction of patents, and invalid and improper patents, unavoidable under our system of granting patents with so brief consideration, with an average of 24 hours consideration, and yet with years of delay.

Chapter 8

FUNDAMENTAL INVENTIONS—NOBODY'S BABY

A. Introduction and Instances

[324] When we discussed in chapter 6 the numerous classes of inventions and discoveries for which patents are usually not sought, even if legally and economically feasible, we left (¶ 214) for consideration here the case which is the most important, the *fundamental* civil invention, the grand new start, most important intrinsically and because it has no present means of support. Science has its universities, foundations, and Government bureaus; fundamental military inventions like atomic energy and space travel have their Defense expenditures; gadgets and improvements below the patenting level have their commercial motives, for quick even if limited profits; but the fundamental civil invention is nobody's baby, and lacking all help languishes long, far longer than the 17 years of patent protection. Let us first illustrate this by four cases.[332]

[325] *Television* was first embodied in apparatus in 1877, its uses and consequences pretty well foreseen in 1892 and 1912,[333] and Fessenden [334] designed and tried out a wireless system in 1901. But its earliest important use in America was about 1947. In those 70 years many men had labored and spent on it, adding important elements such as the scanning disk, radio operation, broadcasting, and Zworykin's key invention of the iconoscope in 1929, 18 years before the patent rewards could have become important. He had taken his first TV patent in 1923.

[326] The *helicopter*, including the first screw propulsion, was proposed by Leonardo da Vinci about 1500, but might have been in use before then in China, as a flying toy.[335] Long and painful development of the invention was pursued in the 1800's, parallel with the airplane. It got off the ground before the century ended, was experimented with by Edison in 1908, flew usefully on a tether in the first World War, and free in 1922, and in 1930 the aviation authority, Klemin, wrote "The amount of money, ingenuity, and trouble spent on the helicopter without tangible results is extraordinary. It is one of the mysteries of aeronautics as to whether success will ever be attained." [336] However, this most expensive bird flew successfully in Germany in 1938, and the first sizable orders for it were placed in 1943, when the American military had taken it up and when all the essential patents had expired, including the method of control by cyclical readjustment of the rotor blade angles.

[327] *Jet propulsion*, in water or air, is found in nature, was proposed by Bernouilli in 1738, has been experimented with for centuries,

[335] This "flying top" had coaxial propellers, energized by a bent bow, and was exhibited in Europe in 1784. Other history may be found in D. Francis: *Story of the Helicopter*, 1946, 182 pp.; and S. P. Johnston: Flying Up; *Technol. Rev.* 43: 64ff., Dec. 1940.

flew in a helicopter model of 1842, first flew a manned airplane in 1939 or 1940, but attained a practical (military) use only in 1944, when the British and German armed services had developed it for air warfare. Its possible uses for propulsion in water, long claimed, remain unattended and probably uncertain.[337]

[328] The *voice-operated writing machine* may be taken as a representative of the many great fundamental inventions that will be realized in the future, are needed now, and could probably be obtained rather shortly; but instead we shall have to go without them for many years more, because neither patents nor any other reward are available to stimulate the inventors and to reimburse their great expenses. This invention was seriously proposed in 1892, reduced to practice by Fessenden in 1907, and brought to write a legible line by Flowers in 1916.[338] Then the great Bell Telephone Laboratories developed something of the sort, the vocoder, and later "Audrey" to recognize carefully spoken digits,[339] all to meet their own needs, but not full writing machines. Still other acoustical devices will, if developed, give a sense of their surroundings to the blind. A Swiss, a Japanese, and an American have been reported in the last decade as working on writing machines,[340] and as usual "close to success" with a typewriter, and later MIT, the Bell Telephone Laboratories, and three others [341] have all been working toward this very difficult device. But the years go by while we do without, and the patents go on expiring. L. C. Smith was said to have backed Flowers, but it could only be for philanthropy. For the voice-operated typewriter he was attempting would necessarily be totally different from the "Elsie Smith." A voice-operated writing machine need not necessarily be a typewriter, but might trace lines infinitely variable but still legible. For many purposes though it will be much better to encode speech into a typed alphabet, which could be read photoelectrically as well as by the eye, as we shall mention anent reading machines (¶ 336). But for any voice-operated writing, and for easiest mechanical reading, we shall need not only the invention of these machines, but a whole new alphabet and conceptions of our pronounciation and spelling. Such difficulties will doubtless defer the invention's use past the 17 years of a patent; and our present system offers hardly any other reward for such delayed inventions, unless they offer hope of serving war, telephony, or some other well-provided-for industry.

[329] We have spoken (¶ 216) anent custom-barred inventions, of how all novelties that interfere with established standardizations, and above all with our world-wide-standardized and ownerless customs of speech and writing, which no one in the English-speaking countries claims any authority over—how all such inventions are almost prohibited and normally unthought of. Yet progress and inventions here could be worth many billions, since *Language* (and thereby communication and cooperation, learning and thought) is a supreme trait of Man, and Reading, Writing, and Talking form our most important industry.

B. Statistical Evidence

[330] Our four discussed fundamental inventions can serve for illumination, but only Statistics can bring proof in social science. But statistics are very hard to apply to invention, as we have explained in ¶ 52,3 and elsewhere,[49] chiefly for the reason that "im-

portant inventions" can hardly be defined and therefore hardly be counted. But their statistics can still be worth something when intelligently prepared and interpreted, with no accuracy claimed. One test was on a group of 19 of the most useful inventions introduced in the quarter-century before 1913, as selected by vote of *Scientific American* readers.[342] Average (geometric mean) intervals were found: between the date when the invention was first thought of, and the first working machine or patent, 176 years; thence to the first practical use, 24 years; to commercial success 14 years more; to important use 12 years further; or say 50 years from the first serious work on the invention, to important use from it. As a check on these averages the author took 3 other lists of inventions he had prepared for other purposes. One list,[343] of the 75 most important inventions which became prominent in 1900–30, showed a median lapse of 33 years between the dates of the first working model or patent and the date of commercial success, in place of the 24-year geometric mean above. Another list[48] covers 209 of the more important nonmilitary inventions introduced with commercial success between 1787 and 1935. Its median interval, between the first serious work and commercial success, for the inventions started before 1900, is 37 years. The arithmetic mean is much longer, 117 years, even after adding 9 centuries to each Ancient date, to close up the relatively stagnant Medieval period. Without considering the ancient starts, two modal points were noticed, at 55 and 35 years. Among the inventions commercialized *after* 1900 the gestation period was much shorter, with a mean of only 9½ years, doubtless largely because of the limitations imposed, since the invention had to be recognized as important for its social effects by 1935, and yet have become commercial not later than 1900. But there may also have been reflected some speeding up of the developmental process, under modern conditions. A fourth list, of marine inventions on which sufficient data could be found, dated 1807–1926,[344] gave median intervals between the first plan and commercial success afloat, of 90 years, whence to important use afloat took 9 years. The findings of the four lists confirm each other as closely as one could expect from the nature of the data.

[331] The earliest period we attempted to measure, from the date the invention was first thought of, to its first working machine or patent, is very unreliable, but of significance in that it shows a long period, whether 176 years or any other large number, during which the possibility and utility of the invention have been perceived, so that some exploratory work could be done on it if it seemed feasible for the times, and if there were some social mechanism that could support the fundamental research work.

[332] The more important gestation periods for us to consider come after that first period of conception, being from the first serious attempt at solution, to the first commercial success, 33–50 years, and the following period before important use, 10–12 years, assuming that those terms can be sufficiently defined to be meaningful. Adding these two periods together, we may say roughly 40 years plus 10, total 50. And there are scarce any inventions to be found that came in much quicker.

[333] *Why* have these basic inventions been so slow to develop? It has not usually been because they were not wanted. For they were all held important subsequently, and they were usually much wanted, at least later. They were by no means average inventions, but the best. But because they were fundamental rather than improvement inventions, striking out in new lines, requiring multifarious new detail devisings and discoveries, they were hard to carry through, and took long. Taking long, they overran the 14–18 year term of patent grants, so that only improvements added in the latest period of development could have protection during large commercial exploitation, which alone could give a worthy financial reward, or even much psychic reward of widely recognized achievement. Thus almost all the pioneer inventors in question, or their backers, had to work for nothing in cash, and little in fame, unless perhaps in old age or posthumously. Borkin and Waldrop say "Of the 40 men who did pioneer service of a major nature to bring radio activities up to a reasonable standard of technical performance, only 2 ever received any appreciable monetary reward. One died with an estate of less than $150,000 (Marconi) and the other went bankrupt (Lee De Forest)." [345] One might amend that Fessenden, though he had received nothing from his first 300 patents (and applications) on wireless and other communication inventions,[346] finally won $2½ millions, at 61 years of age, with 500 patents, and died 5 years later.

[334] Any pioneer inventors having the sagacity needed for their most demanding craft could foresee that their labors would probably go unrewarded, by patent or otherwise, and their outlays probably never be repaid them. Fundamental inventions, like the steamboat, airplane, helicopter, and television are particularly expensive ones. It stands to reason that men with brains enough to succeed in quests as hard as the Holy Grail's, will perceive the odds they face, and usually do something more promising instead. Or if they try nonetheless, continued failure, dissuasion, and bankruptcy will in most cases bring them to a halt, as with almost all the inventors who built 34 steamboats before Fulton's success.[347] And today when, as the statistics show,[348] the decisions whether to undertake or continue a fundamental invention are typically made by noninventor corporate or governmental executives, rather than by enthusiast inventors themselves, these considerations must run stronger than before.[349]

C. Basic Inventions We Are Therefore Missing

[335] There are many other babies beside the voice-operated writing machine begging for a chance to grow to greatness, doubtless more than we could ever find and list, for they are so obscure. These

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[348] Cf. the phenomenal rise of real expenditures for *organized* research, in graph 3, and the rise in percent of patents assigned to a corporation, from ¶ 116.

[349] H. H. Villard in his useful study of Competition, Oligopoly and Research, says: "A corollary of this analysis is that the *more* important the invention, the *less* important is its achievement to the individual firm, which I offer as at least partial explanation of why FM was developed by a college professor and the jet engine by a junior officer of the RAF. For really basic inventions cannot be denied to competitors and therefore do not disturb competitive relationships nearly as much as falling behind in year-to-year improvements. The radio industry, for example, was quite content to let RCA develop TV on the ground that RCA would inevitably have to license its patents, and license them reasonably, if it was not to be prosecuted under the Sherman Act." Farnsworth's efforts were a unique case of effort *for* patents. *Jol. of Pol. Ec.* 66:483–97, 1958, p. 492.

new fundamental inventions have been born, they exist in dark corners, they have proved their possibility, and their capacity to confer immense benefits, but they are not yet practical, nor viable, able to pay for their own development, unless perhaps in some minor use. They have been born in a sort of trap, a no-man's land, where help is available at several boundaries, but only if and when they can manage to crawl to one of these; and the crawl without assistance usually takes many years. One of the escapes is to attain general practicality, or an evidently near enough approach to it so that commercial assistance, and even hopeful patents on details, will be obtainable. Another boundary for escape is the military—if an inventive idea can show a fairly early potentiality for war use, the Defense Department may take it up. Likewise for atomic inventions, and for agriculture ones (if not a typical machine like the century-old cotton-picker,[350] such as are always left to commercial "enterprise"), and perhaps for the postal or other Federal services, or for medicine, astronomy or any other science which rates as pure and noncommercial with our universities and most foundations—for invention in all these domains there is some support available, even if not enough. There are a few foundations, and the governmental Office of Technical Services, which help a few inventors near the practical stage, which we shall discuss in chapters 9 and 10. And, finally, there is the escape route of limited, particular-purpose usefulness, like the telephonic uses for work on vocal sounds, which have helped as well as hindered the telegraphone (¶ 317), and furthered voice operation (¶ 328), likewise various minor marine uses of jet propulsion (¶ 327), and fractional distillations of liquid air, and of sea-water (¶ 353). These special uses assist, but do not grapple with and conquer the main problem we are considering, the major invention, for example, the problem of separating and finding uses for almost *all* the fractions of air or sea water, *cheaply* and on a vast scale. We acknowledge that through rare uses the fundamental inventions do find some aid and in time make their escapes to glory, but we are concerned in this chapter with how they tarry for decades and even centuries in the no-man's land of little or no support, and with how this fact is vastly ruinous, and unnecessary if we had some institutions adapted to this great need. Our first group of languishing and highly needed fundamental inventions is in the field of communication inventions.

1. Communication Inventions

[336] *Writing machines*, voice-operated, we have just discussed (¶ 328,9). *Reading machines*, able to read printed or typewritten material and translate it into appropriate actions, such as sorting mail or cards, charging postage, detecting counterfeits, counting money, doing bookkeeping, translating languages, setting type, or transliterating a book, journal, or typed letter into sounds or tactile stimuli understandable by a taught blind person, could all be of enormous utility, especially to the sighted majority, since Reading and Writing is our greatest industry. All of these reading activities have been mechanized already in more or less clumsy fashion, often requiring a preliminary transcription by hand and eye onto cards or tape, a bottleneck of slow and expensive work. Some inventive progress is

being made by the Post Office,[351] Census Bureau, telephone company, IBM, RCA, Veterans' Administration, OSRD, MIT, and various isolated inventors, but no general attack on the whole problem for all purposes. A foretaste of what might be accomplished is afforded by the Census Bureau, which from the original schedules punches cards and turns out completed, totalized, cross-tabulated, printed census volumes, without human activity, except to supervise the machines which read, compute, write, lithoprint, etc. The new art of Fiber Optics may help, whereby light can be sent along a flexible cable of quartz or glass fibers, each fiber conveying a different series of light impulses, from viewing a different part of a letter or picture (¶ 361).

[337] *Microprinting* is an art that ought to repeat, but faster, the history of its sister art Microfilming, which made a brilliant start in the pigeon post of besieged Paris in 1871, but has only recently come into wide use. Edison, Admiral Fiske and others have produced micro books, with, e.g., 72 pages put onto an ordinary 3 x 5 library card; but we still lack handy apparatus for producing and for reading them, e.g., by projection onto a wall, and wide diffusion of the reading machines, as with radio sets. Publishers of books, magazines, and newspapers show no interest in such inventions: naturally, they had rather sell big books at big prices, than tiny ones cheap, such as an encyclopedia in the size of a pamphlet. But the interest of the consumer, and of a well informed nation, is to have printed matter cheap and of almost no bulk, so that every middle-class home might afford and contain a sizable library of permanent and periodical literature and pictures. This form of miniaturization is a typical "nobody's baby," that almost everyone wants but no one is rewarded for raising. Grave copyright problems are also involved, since microfilming makes easy copying of print.

[338] *Radio facsimile telegraphy*, which would above all serve to broadcast newspapers to be printed in our home, recorded and preserved on microfilm, is an art related to the miniaturized book, and like it having a long past, a great future, and very little present. In wired form it was first patented in 1843,[352] developed to send photographs by Amstutz in 1881, and made practical by Korn in 1902. Radio transmission was attempted by Fessenden in 1906–14,[346] and was commercialized for radio photos across the ocean in 1926. It has since been developed to considerable perfection for news photos, and just before the Second World War was tried out by a number of newspapers in the form of an edition broadcast daily or hourly by radio, complete with photographs, drawings and advertisements, but in reduced readable format, to be received by anyone owning a suitable set. But when no way could be found to make such a radio newspaper pay for itself, they gave their apparatus to universities, and only the military and the *New York Times* continued in the field.[353] It is strange to find an invention of such unique power and obvious utility, that has gone back. A legal change could enable it to support itself, e.g., the privilege of taxing the special paper for home reception, commonly electrolytic. There are high advantages in a newspaper that could be delivered to every reading home mechanically, immediately when any news breaks, at any hour of the day or night, or at hours chosen by the subscriber, without his attendance, received and read silently, with pictures, and only those portions read that interest the

reader, whereas with spoken or televised newscasts one must hear through all to hear any, unable to skim pages for what concerns one; and one must take it in at the speaker's speed, not according to one's interest or understanding. One would set one's machine to receive only certain bulletins, just as we subscribe for some and not all magazines. With a transistor one could leave the machine always on the alert. Reception would probably be by a snapshot on microfilm, of a page of printing and pictures momentarily exposed on a television machine, of the type described next; and the film, of such little bulk, could easily be preserved as long as desired.

[339] *Television*, radio, and the home movie and talkie, after long floundering in the doldrums of nonsupport, have at last attained such abundant use and commercial support that they are hardly to be considered in this chapter on "babies." But so vast is their future importance, especially television's, as the principal door to people's minds and therefore to the control of fundamental politics and our whole civilization, that its development merits the statesman's attention. Better color TV, a more detailed and larger picture, probably projected on a wall or special screen, with three dimensions, binaural hearing, and means for recording it when desired, in a microfilm snapshot or continuing film, are developments to be expected. One that our laws might make universally obligatory would be a transistor in the set, on perpetually current but "currentless" watch, so that a governmental radio signal could turn on all sets at any hour of the day or night, to call out a warning and instructions on approach of a bomb attack, tornado, flood or other disaster to the area, much better than sirens. Home talkies need the same improvements as TV, and especially to become cheap and simple to operate, on films borrowed from public and school libraries. They could use the same projector and screen as the TV.

[340] *Point-to-point* wire circuit television could use the same, too. It is just now starting a brilliant career in education, industry, military, and scientific employments, and needs to be spread to countless other uses, less important singly but *more* important from their vast number. When desired and paid for it could add to the telephone the faculty of sight, by which we receive 85% of our impressions, enhancing the telephone's value in the same measure that television improved the common radio. One might thus see a friend or a business contact, while talking over a document, drawing, map, table of hours, sizes, prices, or see a merchant's goods and have him demonstrate their qualities, perhaps under a magnifying lens and in natural color, giving a better view than if one stood at his side. One could even sign a check or other promise by authenticated TV. Scurrying about town would become largely unnecessary, a particularly great relief to shoppers and the growing suburban population. The telephone company has recently patented an imperfect system for thus using its wires.[354]

[341] *The audiovisor.* All the communication inventions we have just been discussing, viz., the micro book, radio, home-printed newspaper, broadcast, and point-to-point TV, recorder for the same, and home talkie, plus some other desirable devices, such as a phonograph, tape recorder, telefax for sending and receiving Ms., telegrams, checks, and pictures, telephone recorder and transmitter whether one be at home or out, camera, and microfilm recorder—all these devices would

need much the same electric, radio, telephone wire, acoustic, optical, projective, and microfilm equipment. It would be logical, therefore, to combine most or all of this equipment into one big apparatus, that might be called the audiovisor. It would be an expensive machine, like an automobile or a furnace, but it would be an indispensable one for leading a truly civilized life, in touch with the minds, speech and view of other men, through all space and all time. As such it would certainly fall in the province of the national Government, to regulate, standardize, use for public instruction and warnings, and also to *invent* such parts of it as are taken care of neither by commercial motives nor by our present governmental inventive programs, almost confined to war and fields other than communication.

[342] *Music*, of ever higher character, has become a main feature of our mass communication, including not only broadcasting but the cinema, phonographs, shop and outdoor music, etc. The character of music is largely determined by the instruments and voices which produce it: it is said that the inventions of the organ and the violin greatly affected the character of music. It is most surprising that since the pianoforte about 1720 A.D. no musical instrument of major importance has been invented, only the saxophone, accordion, reed organ, theremin, electric organ, and electric guitar, etc., while most of our instruments have been improved only by minute refinements, whereas invention in most other fields has had a vertiginous upsurge since 1720. As for vocal music, there has been no important invention since the introduction of harmony. One would suspect in music a failure of personal motive for invention. Is the case not that musical instruments are manufactured by small firms, each making only one line, and are bought by musicians and pupils who invest years of time in learning to play one instrument; so nobody has any interest in a radically new kind of instrument, that he could not manufacture, nor play, nor find anyone to instruct him in? Each man's pleasure, prestige, and profit are tied to excelling in the use or production of a particular, traditional instrument; so no one has a motive to invent anything but trifling improvements.

[343] How could invention in music be so activated, by new social arrangements for the support of invention there, so that music might be further improved, as have so many other sides of life in recent centuries? In brief, it could be done by advancing music from the handicraft stage in which it now languishes, to the factory and scientific stage. Music is produced today usually on portable hand instruments, or sung with no tools at all, unless it is played on a sizable machine—piano or organ. All of these must be standardized so that good musicians can travel about to reach wide enough audiences, either carrying their instruments with them or depending on the standard design of the instruments they will find on arrival. Yet a new era of possibilities is already opening up, in the recording, reproduction, and multiplication of music, through such inventions as the phonograph, jukebox, sound films, loud speaker, radio, and television, whereby one musician or group can perform for millions of auditors, at one time in one studio. Hence they can be well paid, for a most distinguished performance, and essentially they need never travel, nor require portable, traditional nor standardized instruments. Playing to the whole world, they could afford an instrument, studio or music-

factory that took a thousand men to operate by techniques used nowhere else, weighed a thousand tons, and cost $50 million.

[344] Such a vast enlargement of the permitted nature of the instrument would naturally lead to the invention of one or more very strange, novel instruments, and to the composing of new music for them, with great improvements like those brought in by the inventions long ago of the organ, harmony, and violin. We could replace our tempered intonation by reviving the natural, "just intonation", which today we hear only in the beautiful, ringing chords of *a cappella* choirs. The "just intonation" in a piano would require twelve times as many strings, but in a world music instrument would be easy. Such an instrument was invented and set to broadcasting by wire, partially developed, $200,000 worth, with much artistic success in the Telharmonium of Cahill in 1907; [355] but it was bankrupted by the war, the competition of radio, and other difficulties.[356] We could also use quarter intervals like some folk music, 24 to the octave, instead of our 12. We could invent new timbres (tone qualities, instrument equivalents), and give to each one a range of ten octaves, and varied envelopes, e.g., to add sostenuto continuance to a guitar's pizzicato. Best of all, we could make sounds synthetically, scientifically, taking all the time desired to shape each note, starting by drawing ideal sound waves on paper, then combining these paper curves and finally sounding them, just as a composer or poet selects each note or word with care and time. But today for final performance we must depend on split-second technique and cooperation by two to a hundred musicians, and on whatever limited sounds their ancient instruments can produce. A synthetic singer or orator might be given a range of seven octaves, enunciation of the utmost clarity, and musical tones more beautiful, or speech more winning, than any we have heard or imagined. This would be combined with a visual projection of an actor or an animated, three-dimensional color drawing. The possibilities, for art, for advertising, for persuasive propaganda, education or reindoctrination, appear limitless.

[345] Such synthetic music, starting with the drawing of the waves, was proposed in 1892,[353] and imperfectly realized in 1932. Mechanical production of voice-like sounds has been tried for centuries, and advanced to comprehensible quality by the telephone company in its Vocoder, seeking the limited purposes of telephony. Neither invention is likely to realize its enormous potential for many a year in the future, unless scientists are set to work on it, with different means of financial support from any it has today, presumably by cooperation between the Government and the whole big industries to be benefited. Ordinary patents would be no use at all. The business must be highly concentrated from the start.

2. Inventions for Indexing Things and People

[346] *Documentation*, supplying to researchers any information extant and available in the world, is another big field where invention is much needed and little supplied. Development here is crippled because those who directly need better documentation, the scholars,

[356] Modern electric organs and experimental "electronic music" embody some of the telharmonium's ideas.

inventors, libraries, universities, governments, and firms, are scattered and either weak, or do not need better documentation so much right now, but what some familiar makeshift can suffice. One can usually find any published fact and some in Ms., by exhaustive hunting in all languages through all the world's big libraries. The periodical indexes are rather well worked out, but burdensomely subdivided by field, language, and year, in hundreds of volumes. Corporations, governments, and other groups build up their own libraries to serve their own purposes more or less well, however unprovided they leave the rest of the searching world. The usually defeated struggles of the Patent Office we have discussed (¶ 295). The Office is now embarked on a fine program of devising mechanical and electronic means to search and index chemical and wider literature, and so are the Libraries of Congress and the University of Chicago. The Russians, too, have highly developed documentation;[357] but its general world situation reminds one of the Panama mule path. This 40-mile transisthmian route was one of the world's most important highways, yet for three centuries it remained cobbled with boulders and impassable to any transport better than pack mules, because it was always easier for the time being to continue using it, than to build a road. We obviously need a national or international single index to all recorded knowledge, in which would be collected detail citations or the material itself, or a microfilm of it, and the library locations of all rare texts in the world, with search and translation difficulties minimized by all manner of known devices and others to be invented, for indexing, mechanical searching, making, and reading microfilms and other documents. It should also provide that best cross-referenced of all indexes, human minds, in the form of experts and translators present, or nonresident but cataloged as to their ultimate specialties. A letter or phone call to such a knowledge-center could promptly bring a full and easy answer to almost any question that has ever been answered in the past. It would therefore be an invaluable help to answering *new* questions, as to inventions and all other problems. Such an international research library helping hourly all the world's key inquirers and creators, would also be a great aid to international understanding and good will, through the sociological principles that people become like-minded through acting together to meet common problems, and that they gain respect for their proper teachers through learning who these are, who knows each thing best.

[347] One sort of documentation is a certain great art of interest chiefly to civil government, and therefore dilatory inventionwise under present conditions: the art of *indexing people.* We have, to be sure, made progress, we now take for granted in our newspapers, e.g., that everybody of interest is to be identified by his two or three names, age, sex, and address, while more particular documents add his telephone and often his Social Security number and signature, and sometimes his portrait and fingerprints. Our greatest problem is with our most obscure people, criminals, most resolute not to be indexed and known. We have learned to file and make available many records on

[357] The world's science comes in 30,000 periodicals and a million papers a year, with a backlog of 100,000,000. C. M. Mooers: Info. in a Hurry; *Chem. Engg.* 57:297–9, Nov. 1950. The Russians are publishing each year an index of the world's sci. literature, as big as the *Encyc. Brit.*, with 8,000 journals abstracted by real scientists. *Life,* Dec. 16, 1957, p. 117.

such, including portraits, but can *index* only a few of these, viz., fingerprints (replacing the earlier Bertillon measurements), and MO (*modus operandi*), aside from indexes of address and telephone, used for other purposes chiefly, and the marks of laundries and dry cleaners. Indexing multiplies the value of records several fold, since it enables identifying the individual and locating all his records, given a single later observation of him, such as fingerprint, or an account (MO) of a new crime. It would be an immense help to law enforcement, and so to all of us, if we could invent ways to *index* faces, ears, handwritings, and voices, now increasingly recorded by cameras and acoustical devices. The telephone company has made a start toward indexing voices. It does not seem too much to ask, that whatever the unaided human mind can perceive, remember and recognize as unique, the mind aided by scientific measurement and recording, should be able so to catalog and index, that another mind later meeting the same should be able to seek out, look up, and identify the individual, just as with fingerprints.

[348] In the same field of police, and also of mental health, lie many other nascent inventions needing more vigorous development, especially lie detection techniques, and mental and psychoanalytic tests, including graphology. This latest science, of reading character and personal history from handwriting, has proved its power, and while it is not, of course, the *best* way to read those traits, it is often the only way available, or the only easy one, as when a vanished criminal has left some writing, or an unknown letter-writer asks credit. As for lie detection, it gives promise of becoming able to read the mind, willy-nilly, completely. Possibilities of abuse? Of course, and possibilities of proper administration too, and of great benefits, including the proof of innocence and good character.

3. Cybernetic Inventions

[349] Science finds commercial support only in minor degree in even most recent times; it depends chiefly upon government and on universities and other philanthropies. A great new field for interlocked science and invention, one supplying the ideas and the other the devices to utilize them may be called Cybernetics, or the science-craft of perceiving things and acting accordingly. The human senses, mind, memory, and hands are to be understood, imitated, supplemented, improved, and partly replaced, not only through invention but through physiologic study of the mind and nervous system of man and other animals. Such studies, and the new Communication Theory, have been involved with others, in inventions previously discussed, for television and other communication, documentation, automated libraries, indexing personal traits, and synthetic music. The vast and fast growing field of Automation, with its devices for measuring, recording, and controlling, is likewise involved. A great new light begins to be shed by the electroencephalograph and similar measurement of electric potentials of nerve impulses—means of following and measuring the mind as it thinks and acts.

[350] Inventions to enable the blind, deaf, and crippled to overcome their handicaps are some minor fields for cybernetics, and should have noncommercial support, since we believe that society owes help

to such people, and their fewness hampers commercial sustention. Some remarkable starts have been made, but only starts,[358] on inventions enabling the blind to sense their surroundings, and to read ordinary print (¶ 336), and the deaf to hear with no ear at all. Again, the usual sequence of stimulus→thought→action has been reversed, just as the sequences in mathematics, physics, and chemistry are often reversed. A chimpanzee was induced to wave his arms, and his concomitant brain waves were recorded. Then these waves were played back into his head, whereupon he waved his arms. Does this mean that we could automatically, electrically put ideas into a person's mind? If so, we would have a great invention for man's colossal problem, the better ordering of the minds of men.

[351] An easier cybernetic invention-class, already started like all we discuss, and one peculiarly requiring the cooperation of civil government, is the *safety control of automobiles*. Devices like automatic seat belts, that will protect riders whether they bother about their lives or not, anticollision devices such as the headlight dimmer (¶ 222), and above all automatic steering and speed control, are babies needing adoption. As ships have been steered through mine fields, by electrically sensing and following a cable pulsing with alternating current on the harbor bottom, so automobiles could follow in any weather cables buried in the roadway, proceeding at speeds uniform, swift, and safe, while the (occasional) drivers occupied themselves with the scenery, TV, or what they will.

[352] We might add here an invention which one would think commercial enterprise certainly could and should have provided—automobile locks able to protect a car and its contents from thieves. But since private enterprise has failed to supply this, during fifty years of need, perhaps the state should take up the problem. For an additional motive, we are concerned to stop a principal inducement and support of juvenile crime.

4. Other Electrical Inventions

[353] Governments are very active toward securing power from *atomic* fission and fusion. But even more valuable might be development of burning coal in the mine, to produce electricity, heat, gas and/or chemical products, as the Russians and others have been doing experimentally. It would also remove smoke from our cities, reduce the unhappy trade of the coal miner, and economize our natural resource. Government inventing is also appropriate for *power directly from heat* and light,[359] as in some recent military and Telephone work on solar and other batteries.[360] Perhaps Government should also do more on *radiation sources* emitting only alpha and heat rays, easy to shield, safe, and available for minor engines like an autombile's. But this is inevitably tied up with the propulsion of space craft and planes and other war transport. Low temperature-differentials, if they could be efficiently harnessed, could yield abundant power from tropical surface versus deep seawater, or from northern ice versus the underlying water. Much the same needed inventions and scientific discoveries are tied up with the fractionation of *seawater*, and of brackish or alkaline waters abundant in various regions American and foreign, to yield locally scarce fresh water, and separated salt with its numerous

minor constituents, including sodium, chlorine, bromine, and magnesium already being extracted, and iodine, potassium, silver, gold, etc. Long featuring in this author's lists of invention infants crying for adoption, the better extraction of fresh water from marine or brackish sources was taken seriously in hand by Congress in 1952, as well as by eight or more other nations and by commercial enterprise. Our Office of Saline Water had 40 projects in hand at once, mostly farmed out, with a budget of $825,000 for 1959, $1,750,000 for 1961, $12.5 million estimated for 1964, and such growing success and use reported over the world as to demonstrate what a government can do with a fundamental civil invention, which has been struggling along since ancient Greek times. There are a surprising number of ways for separating salt and water, but none is easy to make cheap enough, since the unavoidable energy input equals what would raise the water 1,000 feet.[361]

[354] *Electroluminescence*, and *chemical luminescence* are two new general ways by which light might be produced with much less heat and required energy than today, and with inviting architectural features of wide, softly glowing surfaces. Our experience with fluorescent lighting (¶ 316) suggests that private industry may need prodding to reduce its market for current.

[355] The control of *smoke*, *smog*, and *dust*, from automobile exhausts and all the other myriad sources, is a problem of growing importance and realization, which private industry can never solve nor even help much, because the creators of the nuisances afflict others much more than themselves. They would lose more through the costs of the abatement devices, and a thousandfold more if they had to invent them, than they would gain for themselves. Yet they are afflicting a whole city, and helping kill people, as has happened tragically in Donora, London, the Meuse Valley, etc., and may also be happening daily through lung cancer. Hence many cities have asserted control over their air, and the most afflicted ones, Los Angeles County, Pittsburgh, and St. Louis, have done much about it. But still they have not embarked on *invention*, which we showed is ever neglected for inventions not assessable upon their beneficiaries (¶ 222,3). It is evident that invention will be most logically and liberally supported, when the whole collection of those who will benefit by it, join in paying for and ordering it.

[356] Similarly with water pollution, noise control, fire fighting, crime prevention, and a host of inventions for the safety and health of men, animals, and plants, as we said anent the almost total failure of cities and State governments to create the inventions they need (¶ 224–6, 347,8). Unless our Federal Government takes them up, or private enterprise discovers a way to make money from them, inventions in such fields remain in the forlorn status of "everybody's business, therefore nobody's business."

[357] *Shallow geophysical prospecting*, i.e., devices like the mine detector to discover objects lost and buried under a few feet of earth, or on the bottom of shallow seas, lakes, and rivers, can have immense value to archeology, history, paleontology, and all the sciences relating to a century or more ago. The most modern lost objects of interest, such as treasure, and buried pipes and wires, are usually of metal, and so can be found by the electromagnetic military invention of the mine detector. But more ancient objects, such as carved stones, charcoal,

and bones, need much difficult inventing for their finding. What would the learned world not give for multitudinous sculpture and artifacts from the ancients of all lands, and for carved writings, and bilingual "Rosetta stones" whereby to read them, of the Picts, Iberians, Etruscans, Mayas, and a hundred other peoples of earliest history! And for implements and bones of their and our ancestors back for millions of years! They are lying beneath our feet in countless places; but we must invent the means to find them, by reflected sound waves or whatever it will take.[362]

5. Other Biological Inventions

[358] With the world's exploding population, and our own people among the faster growing, a shortage of agricultural land is a problem almost everywhere. If we mean to accept and continue the explosion, we shall probably need some radical inventions to increase the food supply in quantity if we are to hold our level of well-being, and in quality too if we are to raise this. One means is *hydroponics* (soilless agriculture), with which there is no limit to the food that can be raised per acre, in greenhouses multistoried and flooded with perpetual artificial light. But this will take much development of growing methods, special harvesting and building machinery, new adapted varieties of plants and animals, economical light of the best colors, and much power supply. The most immediate and sure recourse, Meier contends in his excellent survey of how invention can meet the world's economic problems,[359] would be the growing of green algae in treated water, for protein and carbohydrate food for poor people and animals. Our abundant *salt marshes* could also be put to use.[363] And with fostered understanding of chemistry, there are unlimited possibilities of *synthesizing food* and other organic compounds directly from the elements. This is already done on a vast scale for plastics, textiles, dyes, drugs, and even some foods. One means of doing so, photosynthesis imitating the chlorophyl by which Nature builds the green world, has been often studied of late, especially through algae.

[359] *Insects* are enormously important for both good and ill; and since they never stay put, on the right side of landowners' fences, they peculiarly need the wide-spreading authority of the nation. Our Departments of Agriculture, and Public Health, are activated to meet them, sometimes with legal authority over men harboring certain insects, oftener with funds for research, invention, and propaganda against tiny pests. Often means for killing certain kinds kill beneficial species too, say poisoning the birds and other life that feed on them. A selective remedy that seems to ask development is to play the mating call of one species, through strategically placed loudspeakers, so as to lure to destruction one sex of that species only. It has been done.[364] Or take another example exploiting the endless variety and specificity of insects' instincts. The female fly of the screw-worm, a tropical cattle pest, mates only once. So swarms of males were raised, sterilized by X-ray, released to find and sterilize females, and so thus their race was exterminated in Curação.[365] A like program has been started here.

[360] The varying minute percentage of *ozone* in the air, and/or the changing *ionization* of the air which accompanies this, seem to have important effects on human health and mental alertness. Although

those phenomena are controlled by weather, they could be manipulated inside buildings. Such facts have long been known; [366] to investigate them exhaustively and put them to work would seem well worth the Government's while. Who knows—the resultant inventions might not only invigorate and prolong our life, but some might even be useful for killing people, and hence rate military funds.

6. Other Inventions

[361] One of the commonest materials on earth is *quartz*, silica, SiO_2. In its pure form it is also one of the most excellent materials, strong, elastic, very hard, expanding so little with heat that it is almost immune to heat breakage, insulating, insoluble, almost impervious to chemical attack, transmits light much better than optical glass, can pipe it around corners, so that a quartz fiber can carry light as a flexible wire carries electricity. In a flexible rope of many fibers of quartz, or less well glass, supplying as well as returning light, this art of *fiber optics* can have a large future, in reading machines (¶ 336) and cybernetics generally, and for inspecting hidden recesses of living bodies or artifacts, and for following a person's head movement, projecting a second picture, e.g., of instrument readings onto his spectacles during fast operations. Quartz is good, too, for lenses, and for precise molds, and it transmits infrared and ultraviolet light, so much needed for health, vitamin D, and germ killing, which all our glass windows, light bulbs, and fluorescent tubes hold back. Yet this so common and capable substance is so scarce and costly in its clear fused form that we rarely see or use it, although it was produced as early as 1901.[367] No law of nature seems to bar the way to making this wonderful substance as common as glass, which is mostly quartz anyway. But the private inventors have failed to make it cheap; so probably the Federal ones should have a long go at it.

[362] *Artificial diamonds* are another such substance, that has been known since 1897, and could be very useful if cheaper, especially for sharpening our ever harder alloys, and for drilling rock.

[363] A *rock tunneling machine*, which would perform every part of this work by power, with a minimum of human participation, has been attempted for a century. Now that we may be digging underground like moles, but in deep rock, to protect ourselves and necessities from atomic blasts, such inventions become more needed than ever.

[364] *Soil solidification*, for quick and cheap building of roads, runways, foundations, and fortifications, is a field of invention of major civil use, which has also caught the eye of the military.

[365] The *prediction* and even the *control of weather*, is another opportunity for science and invention, that War has become aware of, and Peace might still more benefit from.

[366] The prediction of *earthquakes* and *volcanic eruptions* is another much needed field that governments and universities have long essayed, but without definitive success as yet.

[367] Good and cheap *prefabricated houses*, and semimovable types, might be classed as a social rather than mechanical invention, so easy would be their mechanical inventing, if once the social problem were solved, of who were to pay for the inventing, and manufacture the houses, with a large enough market assured to justify the immense

machines, factories, and transportation devices, requisite to fabricate, carry, and erect the houses cheaply, (¶ 219).

[368] Two of our oldest inventions, *weaving* by reciprocating a shuttle among warp threads, and *sewing*, seem to need basic changes after thousands of years. Chemistry can enable a revolution, if the possibilities of Mechanics and Topology have been exhausted. It is possible by chemistry to weld or to glue together fibers, especially of the new synthetic types. Indeed felting and papermaking did this long ago, but with fibers at random and weak. Instead of weaving, or knitting, thread by thread in millions of reciprocating movements, we might simply lay the warp threads together side by side on a board, lay the weft threads all side by side across them with a single movement, weld the two together by pressure and chemical action, and there would be a fabric strong yet elastic and porous, nonraveling, needing no hemming, and capable of endless variation, by three or more layers in different directions, etc.

[369] Next, to make clothing or other articles, stamp out multiple pieces, as today, from various fabrics, and *glue* or *weld* them together instead of sewing. The Russians have done this extensively if not well, and we have lately made great use of paste in shoemaking. Thus pots of plastic could be transformed into a suit of clothes mechanically and fast, by simultaneous, typical machine action, not thread by thread as today.

[370] But the possibilities of invention in mechanical weaving are not exhausted, despite the centuries. As we seek always to replace Nature's reciprocation by Man's continuous rotation, it is possible to whisk the shuttle in a continuous rotary, slightly spiral path around a lengthening cylinder of warp threads in sheds, thus weaving, with normal varied warp thread arrangements, a cylinder of cloth, instead of a strip of it. It was done in France in 1949.

7. Transportation Inventions

[371] The preeminent aircraft of the future, both for peace and war, should be a *combination of helicopter and airplane*, able to take off vertically by rotary wings from a tiny airport, then transform itself into an airplane in order to fly with the speed and economy of one, then reconvert in flight to a helicopter, so as to be able to alight gently, in fog or clear, on practically any land or water in emergency. Almost always it would land at a small airport; but when the need arises to land immediately without one, that need is drastic. Such hybrid aircraft have been produced for years, with the stimulus of military orders, under such names as Rotodyne, Convertaplane, or Vertol craft; but this writer thinks a much more vigorous inventive program should be activated, in view of the craft's evident value for peace and war, especially for its safety, and its obviation of big, costly, remote, and bomb-vulnerable airports.

[372] For fast watercraft and seaplanes, inventors willing to take a long chance have been inventing the *ladder-boat*, as we may call it, or hydrofoil craft, since around 1908; but only in the last few years has it gone into practical use, carrying passengers across straits like those of Messina and Florida. The boat may have three ladders extending a little deeper into the water than the keel. Each rung of the ladders is

a narrow hydrofoil (vane), of thwartship direction. As the boat gains speed these hydrofoils acquire great lift, so that they lift the whole boat until she is clear of the water, and stands only on the bottom rung of the ladders, affording little resistance and high speed, 35–80 knots. At such speed the water becomes like a softish solid, that can be cut through by the sharp, thin hydrofoils, the waves being left below the hull.[368] A danger is driftwood, but the boat could still float and navigate on its undamaged hull. The Government is experimenting with the invention for seaplane uses; much work seems called for.

[373] The *unsinkable ship*, or cabin that would float free and serve as a lifeboat, has been a challenge to inventors for a century, mostly incompetent men. Perhaps assiduous science could succeed.

[374] The *house trailer* we have discussed in ¶ 219, 220. Like the prefabricated and the semimovable house, the problem of its development is essentially an economic, a social one, of securing sufficiently large-scale, unified invention and production, paid for by all the consumers of the idea-and-thing, or by the fisc.

[375] Somewhat similar is it with the movable house for goods, or *freight container* as it is called, and "piggyback" arrangements. Strong, reusable boxes of a few standardized big types, that can make a load for a truck or trailer, and be readily shifted into freight flatcars, ships' holds, and terminal buildings, protecting the goods within from damage, the grave evil of pilferage, and need of rehandling, and which must be almost assured of a return load from whatever part of the world, as are ships, freight cars, and big trucks—the securing af all these new benefits is only secondarily a problem of mechanical invention, but primarily one of social invention, obtaining the necessary accommodations of interests, and standardization (¶ 221). In such a program the Federal and U.N. authority could be of great help, just as in the case of the standard rail gage, car coupler, automobile road signs, marine signals, and other necessary standardizations of transportation. Needed automobile inventions have been discussed under Cybernetics (¶ 351, 2).

Chapter 9

AN ATTEMPT TO MEASURE THE CONTRIBUTIONS OF THE RIVAL INSTITUTIONS FOR SUPPORTING INVENTION

[376] We estimated in ¶ 139, by loose methods, that around one-fifth of current American inventing and invention-oriented research is motivated by the patent system, and about four-fifths by the dozen or more rival institutions. Now to approach a related question expressed somewhat differently, better using the fairly accurate statistics which are sometimes available in our field. We shall ask in Part A how much of American inventive effort, measured in dollars spent in the year 1953–54, was paid for, and how much was performed by the various sources (governments, firms, trade associations, etc.). The latest available figure will also be added. In part B (¶ 421 ff.) we shall endeavor to eliminate duplications and to sum up, according to criteria that cut across those categories, how much of invention and research in 1953 used patents, secrecy, or monopoly, and how much came from the three great economic sources: Government, business, and philanthropy.

[377] In Part A we shall set down at the right-hand margin by each subject head, the reported money put up, supplied by that source, or our estimate, and its percentage of a total corrected for duplication, for the fiscal year 1953–54 or the nearest available year, and also the amount for the latest year, each in millions of unstabilized dollars. Then we come to the different matter of performance, which refers to what party performed the work, regardless of who *paid* for it. That more important contribution had been reckoned above, regardless of where the work was done. So next we set down when available the general *performance* of R&D, and its percentage. This time we shall not try to restrict the figure to invention proper and its pertinent sciences. Our reason for choosing 1953–54 for comparisons is the help afforded by a simultaneous series of studies then carried out for the National Science Foundation, which will be cited *passim*. All our figures for 1953–54 are brought together in table 7, ¶ 382.

[378] In the next (10th) chapter we shall take up the several sources again, under the same numbers, to consider the favorite and the best fields for each, and where increases are needed.

[379] In counting contributions, we seek to cover invention proper plus such research as we can find in physics, chemistry, metallurgy and engineering. Invention is taken in its common meaning, not that of patentability, and includes even the smallest improvements, but excludes, where possible for 1953–54, research in medicine, agriculture, mathematics, marketing, and social and other sciences than the four included. Our purview is thus somewhat smaller than that of all R&D, as in chapter 3, or of science, because it sticks to the common

meaning of invention, plus the sciences which feed most directly into it.

[380] The estimated totals from which the percentages are calculated in table 7 (¶ 382) and elsewhere, are for funds supplied, 1953–54. $5,652 million. The same total is assumed for percentage performance, where stated.

[381] The accuracy claimed is decidedly less than that betokened by the numbers of digits shown. The shortcomings of all social science statistics are explained in ¶ 9–12.

[382]

TABLE 7. *The supports of invention and its researches*

[For 1953–54, in million dollars. Estimates, and in the repartition of columns 4–6, guesswork. (See ¶ 9–12.). Line 9a, (in italic), for the laboratories of organized industry, is duplicated in parts of lines 6 and 13–15; hence line 9b, in roman, is subjoined for eliminating the duplications. In adding up the totals this line 9b is used. Explanations and sources are to be found in the numbered sections of this chapter, n.e.c. means those not elsewhere classified nor here set down. An * signifies frequent use of patents, a † of commercial secrecy.]

Supporting source (1)	Percent (2)	Total (3)	Government (4)	Business (5)	Philanthropy (6)
Total, unduplicated		$5,652	$3,467.9	$2,104.4	$79.7
Percent	100	100	61.4	37.2	1.4
1. Federal funds, n.e.c.	45.56	$2,575.0	$2,575.0		
2. State funds, n.e.c.	.16	9.3	9.3		
3. Universities [371]	.48	27.0	17.8	$5.0	$4.2
4. Professional societies	.05	2.8			2.8
5. Trade associations *†	.22	12.5		5.0	7.5
6. Tax benefits	14.93	844.0	844.0		
7. Foundations, etc.*†	.62	35.0			35.0
9a. Organized industry†	*51.00*	*2,880.0*		*2,860.0*	*20.0*
9b. Organized industry, less duplication *†	30.71	1,736.0		1,716.0	20.0
10. Suggestion systems†	.60	34.0	5.6	28.4	
11. Unorganized inventors*†	1.95	110.0		100.0	10.0
12. Awards	.01	.4	.2		.2
13. Compulsory license*†	.58	33.0	16.0	17.0	
14. Patents pool and cross license*†	3.71	210.0		210.0	
15. Know-how sales†	.41	23.0		23.0	

PART A: THE OUTLAYS OR INVENTIVE COSTS FROM VARIOUS TYPES OF ORGANIZATION

[383] 1. The Federal Government:

1953–54, funds formally supplied [369] ..... $2,575 m(illion), 45.6%.
Latest,[370] 1962 ..... $7,600 m.
1953–54 general performance ..... $970 m., 17.2%.

The Federal Government in 1953–4 directly supplied about $2,566 millions for the physical sciences only, including capital expenditures, but other large amounts indirectly through its subsidies to higher education, the patent system, pensions, and social security to research workers, and military intelligence, consular, and library services, and above all through the tax benefit reckoned under No. 6 below. The services to inquiring inventors and industrialists, of the Office of Technical Services ($1.1 million in 1959), and what the patent system costs the Government ($8 million, ¶ 196), have been included in our Funds Supplied. The total Government contribution, which becomes $3,468 million (table 7, col. 4) in fiscal 1954, when one adds the tax benefits, rewards, and part of compulsory license (secs.

6, 10, 12, and 13 below), has risen to be a share whose magnitude should never be forgotten, 61.4% in 1954. In the military field almost entirely, and in civil progress largely, American invention takes place today because the Federal Government desires and supports it. The course of past expenditures, Federal and commercial organized, has been plotted in chart 3, in stable money. Repartitions between sciences and services are given in N 369, 370. The tax benefit attributed is much larger than the actual one of 1953–4, because the later, present law has been assumed as then operative. See ¶ 390.

[384] In the above and our following paragraphs, we have not attempted to reckon the amounts spent for education, nor for pensions and social security for researchers, because of difficulty and because the Government, industry, and the other agencies presumably contribute to these latter services for invention in somewhat equal proportion to their funds specifically allotted.

[385] 2. State governments (aside from their universities and agricultural experimentation):

Funds supplied, 1953–54 ..... $9.3 million, 0.16%.

The expenditures of the States for conduct of general R&D in 1953–54, some $220 million, went mostly to their universities, counted below under section 3, and to agriculture, natural resource development, health and welfare, rather than directly to invention proper, estimated above. Our questionable national estimates are based on the 6 scattered States covered in the Government report,[372] which raised 26% of the $15.3 billion for all State purposes, and on the assumption that the 69.5% of their own money represented in their general R&D expenditures, prevailed also for invention, which we guess at only 6% of their R&D. Their other research funds came chiefly from the Federal Government.

[386] The inventive activities of local government are probably still smaller, and we find no data, except on Los Angeles smog control. As stated before (¶ 224–6), local and State governments are great markets for inventions, but produce hardly any, not wishing to use patenting themselves, and having no other way to oblige the many beneficiaries for the needed inventions to help pay for them. Of course the commercial suppliers of State and local government, e.g., fire-engine manufacturers, use patents.

[387] 3. Universities and colleges (proper):

Funds supplied, 1953–54 ..... $27 m(illion), 0.48%
Performance, general R&D ..... $450 m., 8%

The universities and colleges proper exclude the agricultural experiment stations and separately organized research institutes, and their "own funds" include support from State governments. The rather small amount thus contributed, $27 millions,[373] contrasts with the abundance of research performed, chiefly with Federal money. Their great service to invention is through scientific and general education, and pure science research, and providing a good *milieu* and staff for R&D paid for by others. In the engineering schools $64,390,000 was expended, mostly Federal money, with only $3.5 million from the schools.[374] The universities held about 775 American patents, 0.13% of all, mostly administered by the Research Corporation.[375]

[388] 4. Professional and technical societies:

Funds supplied, 1953–54	$2.14 m(illion), 0.04%
Later, 1957 [376]	$0.6 m.
Performance, general R&D, 1953	$1.0 m.
Performance, general R&D, 1957 [376]	$4.7 m.

These societies are more important for organization and communication within their groups, than from their direct work of invention. We have added to 71 responding societies the 20 research-educational cooperatives of more specialized function, contributing half as much, and have sought to eliminate social science, agriculture, etc., and leave only the work for invention and its confluent sciences.[377]

[389] 5. Trade associations:

Funds supplied, 1953–54	$14.2 m(illion), 0.25%
Latest, 1957	$20.0 m., 0.35%
Performance, general R&D, 1953	$5.3 m.

The inventive and appropriate science research work of these 384 associations, which has been described in Study 21 of the present series,[378] we find especially interesting and worthy of vast expansion (chap. 11). For present statistics we have added "37 other cooperative groups" more specialized, and sought to eliminate the work in noninventive and inappropriate lines, as usual,[379] and guessed at a repartition of support between commercialism and philanthropy.

[390] 6. Tax benefits:

Hypothetical contribution 1953–4	$844 m(illion), 14.9%.
Later, 1959	$1,556 m.[380]

This is a very important way in which the Government fosters research. Inventions are naturally long-term investments, and the money saved from corporate income and invested in research would naturally be first taxed as income. But since 1954, and in many cases before that, our Government has allowed such investments to be "expensed out" before reckoning corporate income, unless the money was spent for capital equipment. Eliminating this last, we get a tax deduction of $1,262 million on company research in 1956,[381] which if the same proportions had held in 1953–4, would have produced $844 million. Some of it would come back to the Government through researches planned for civil ends but turning up something useful to the Government. Unincorporated inventors do not enjoy this privilege, but a wealthy patron can back them "without much risk or too much tax." [382] If such a backer wins, it will be capital gains, with maximum 26% tax, and if he loses he can deduct all from his ordinary income, without the $1,000 limitation. One might also think of the tax exemptions to foundations, trade associations, professional societies, and universities, the postal subsidies on their publications, and income and inheritance tax exemptions on their supporters' gifts, bequests, and dues.

[391] 7. Foundations and other nonprofit research institutes:

Foundations, funds supplied, 1953	$5 m(illion), 0.09%.
All nonprofit research institutes, including State and local funds, 1953–54	$35 m., 0.62.%.
All nonprofit research institutes, including State and local funds, latest, 1957–58	$61 m.
Lately, foundations and institutes only, 1957 [383]	$19 m.
Performance, general R&D, 1953–64	$87 m., 0.65%.

These foundations, some bearing such familiar names as Mellon, Battelle, and Armour, are much more important as performers than as payers for research. Their capital expenditures were the main element we have reckoned [384] for the earlier date. Later the institutional category was expanded and State and local funds were included with their own contributions, whence our much larger second [385] and third lines [386] on contributions, and on performance.[387] Latest expenditure (1960) of "Foundations proper" is $7 million in physical sciences, five-sixths in basic science, with the Sloan Foundation leading.[388] The chief researches of foundations are in social, educational, and health fields.

[392] 8. Consulting laboratories and engineering firms:

Consulting laboratories, performance, 1953	$25.5 m(illion).
Consulting laboratories, later performance, 1956	$89 m.
Engineering firms, later performance, 1956	$81 m.

Since these commercial custom laboratories put up only a negligible proportion of their funds themselves, data are provided for their performance only.[389] Some duplication with manufacturing industry is involved, and the 1953 and 1956 data are not fully comparable.

[393] 9. Industry (the organized and counted laboratories):

1953–54 total funds supplied [390]	$2,880 m(illion), 51%.
Same less duplications	$1,736 m., 30.7%.
Latest, 1960–61	$5,990 m.
1953–54 performance, general R&D	$3,630 m., 64.2%.
Latest performance, 1959–60	$9,550 m.

We have first set down the gross sum for this category, including capital outlays of $728 million,[390] making $2,880 million, then deducted from it, to eliminate duplication, the amounts ascribed in table 8 to tax benefits, suggestion systems, compulsory license, patent pooling, and sales of know-how (sections 6, 10, and 13–15 below), thus obtaining the much smaller second line. (Cf. table 7, ¶ 382, lines *9a* and *b*).[390] The other sections are not duplicative in the main, but there are many minor, unresolved duplications between sections, e.g., between compulsory license and patent pooling. If such duplication could be eliminated, probably the net share of fully competitive, patent-relying industry (9b) would count larger, from items 10–15 becoming smaller. *Performance* [391] is seen to be far larger than the net or even gross funds supplied, due to the flood of research done for the government. The average capital equipment invested in R&D was $27,000 per scientist or engineer employed in 1954.[392] The tax benefit was hypothetical, reflecting present law, not contemporary. Cf. ¶ 390.

[394] If we say so little here about such an important support of invention as large industry, it is because the rest is covered in other pages, or is familiar. When we add the unorganized inventors and the other commercial sections, as in table 7, column 5, the supports from business rise to 37.2%, of fully competitive business to 27%, as we should judge.

[395] 10. Suggestions systems:

Value of employees' suggestions, n.e.c., loosely estimated, for 1954	$34 m(illion)	0.6%
Value of employees' suggestions, n.e.c., later, 1959	$52 m.	

[391] Reckoned without supplement for building.

Employees' suggestion systems include a great flood of invention of the lowest grade, (¶ 94, 138) scarce ever patented, rewarded when accepted with an average of only $27.23 in 1954. Many of the good suggestions were not inventions in any sense, but copyings which presumably would be less rewarded than original creations, or were social or other nontechnic inventions. $8.5 million were paid for adopted suggestions reported to the association, and such were estimated in 1954 to be worth $20 million in their first year of use,[111] while several years use is to be expected. We take the trifling figure paid per accepted suggestion, and double it on account of the higher indicated value, and because much must have been spent on evaluating the suggestions (four times more numerous than the accepted), and developing the accepted inventions. Then, because the employees working under suggestion systems were only a fifth of those in such occupations, we guess that those without a suggestion system are producing a fourth as many good ideas per head; adding the two cohorts we get the above total value. To be sure, our estimate is shaky, but probably better than if left out, which would mean in effect setting down 0 as the value and percentage of this somewhat important field of invention.

[396] 11. Unorganized inventors:

Guessed value of 1953 output---------- $110 million, 1.95%

This category must include, beside the strictly unorganized inventors, those in firms having less than eight employees, or in laboratories too small or obscure to get counted in our Government statistics, and the freelance, the amateur, and the crackpot inventor. It is a category peculiarly difficult to measure, because of its unorganization and often obscurity. And it raises the question of whether we should try to measure their invention by their *inputs* of money and effort, or by their *output* of successful, weighted invention. Hitherto in this chapter (unless anent suggestion systems) we have ignored this question, assuming the same amount of success per dollar from the various supports for invention; but with the unorganized group there are strong reasons to think its efficiency much less than the laboratories'. Jewkes, *et al.*, have sought to play up the isolated inventor compared with the laboratory, but without success, since their book [398] neglects statistics, and bases its argument on selected cases, mostly too old to reflect present conditions; and it uses a common but misleading definition of invention. It counts as the invention the first serious attempt to work out a basic idea thought of as the kernel of an important invention. Such ideas do indeed often occur to professors, amateurs and other people outside laboratories. But they occur easily, are duplicated by other men, and so are of little economic value or significance. To label such an idea *the invention* is like calling an acorn an oak tree, or saying a new-laid egg is an 8-lb. rooster—all you need do is hatch and raise it. Particularly from our economic point of view, the definition of invention must consist with *that which costs*, or usually and expectably costs, and is scarce, and precious, because not only scarce but well satisfying some of man's desires, already or demonstrably and not merely in a possible future. Invention thus economically defined is created today almost entirely in laboratories, even if the seed from which the crop is grown with vast difficulty and uncertainty is often contributed by an outsider, even possibly an amateur.

[397] While the propaganda of the patent professions, and the popular stories, not to say mythology, of invention are full of oldtime tales of unlearned and poor outsiders, who thought up great inventions, developed them personally, forced them into use, and for the happy ending made much money, nonetheless today's main truth can be got at much better by today's statistics; statistics which reflect present conditions, and remember the million failures as well as the rare, delightfully memorable successes. Some statistics are provided in a report of the subcommittee.[312]

[398] Schmookler (ftN *99*, p 31) starting from patents, found 20–30% of his inventor respondents claiming that their invention was not part of their job. But we have shown that patents are such a minor motive for modern inventing (¶ 139, 140), and so often bogus (¶ 403), or unworked (36%, ¶ 405), that patents are evidently a very unreliable measure of modern inventing, and offer no assurance that outsiders' inventions are as good as laboratories', nor that they bear any particular proportion to the latter. But for what patent statistics may yield, we shall use Sanders' below (¶ 400–409).

[399] The Institute of Inventive Research at Southwest Research Institute offered help to inventors. In 100,000 inventive projects evaluated they found one really good one (a lift-slab method of concrete construction), four that reached the market, and so little return for a million dollars of help that they gave up the program.[394] An authority estimates that 1 in 2,000 unsolicited ideas has merit.[394] When the Sinclair Oil Co. recently offered to evaluate anyone's schemes for petroleum products and to develop the promising ones in their big laboratory, the result was a flood of projects and practically no success.[395] It is common report, confirmed by Sanders' statistics,[396] and Van Deusen's,[204] that the greatest corporations buy almost no outside ideas, particularly in the auto industry, and in carpet sweepers never.[397] GE is interested in less than a thousandth of the 2,500 ideas submitted to them yearly, although they have 3 men at work screening them.[398] In the First World War government boards were set up in England, France, and America to receive and judge proffered war inventions; 233,000 were received, 1.1% were found "useful", and practically none used.[399] In the Second World War the boards tried harder, and found useful 0.25% in Britain and 4.1% in America, where 0.051% were put in production. At present our National Inventors Council is handling about 900 "inventions" per month, but has brought into use only 1 or 2 in the last 5 years.[394]

[400] These statistics of almost invariable failure today do not mean that unorganized invention is that bad. Doubtless part of the rejections are due to snootiness, the feeling of the inside professionals, military and civil, that outsiders with merely nascent ideas cannot know what the score is, especially in the face of military secrecy. Even the corporate inventor who gets ideas outside his department or his assigned task is said to meet similar rebuffs.[394] Another trouble is the outsider's inability to follow up and improve his ideas, and to advocate them through informal channels. Still other troubles are perfunctory handling, and complete uncertainty of reward in the Government case, and mutual suspicion in dealings between corporations and outside inventors; hence able men with good ideas are inhibited or deflected elsewhere.[394] Whatever the causes, the result is that the un-

organized inventor fails, even if his idea be good, and successful in proper hands. Invention today is pretty much something produced through organized and regular channels. Any outsider or rebel, whether in a corporate laboratory, the Government, or his own basement, who would like to invent otherwise (unless it be some simple gadget that he knows all about), might almost as well think of starting his own great newspaper or his own telephone system or navy. But in the very few cases where he can persuade an organization earnestly to take up his idea, the invention is thenceforth in regular channels.

[401] Better cooperation still seems needed, between the outsider with a possibly useful idea, based on unusual experience or the luck of his large numbers, and the corporation or Government which knows far better what is wanted, what would fit in, and has the means to test the idea, to develop it if promising, and to use it if successful. But such cooperation is very difficult if the inventor is seeking reward for his work. (Usually with the war inventions he was not.) For with no patent yet granted him, nor usually applied for, and with duplicate inventing so common (¶ 146), each side has poor protection against the other falsely claiming priority. Some firms refuse to look at a proffered invention, unless patent had been applied for on it; but this hard requirement is enough to deter all but the most determined and well equipped amateurs.

[402] Our next statistics on unorganized inventing are those from our one important institution to aid it, the patent system. Yet these are not very satisfactory; first because they omit the vast mass, doubtless a large majority by weight, of unorganized inventions and research not patented, either because not patentable, or individually not worth patenting, or because held secret, or because the inventor was too poor, or for any other reason, though some such work has been covered by our previous statistics of laboratories and suggestion systems. Second, we have no means by patents to distinguish the organized from the unorganized inventor, except to assume that the 61% of patents assigned to corporations on issue [400] were made by laboratory inventors counted under our sections 1–9, and that the patents assigned later (3%), or not at all (36%), were the work of unorganized inventors.

[403] The validity of this—our assumption that the ratio of initially assigned to all other patents might be taken as the ratio of organized to unorganized inventive effort, and then reduced a fraction by an assumption of less inventive success (weighted output)—might be attacked and defended on many grounds. But first some more background information. Of the assigned patents 94% are developed by the company's own employees.[401] The 3% of patents assigned after issue go 88% to the small companies of Sanders' reckoning,[402] which received only 36% of the initially assigned patents. Their fields, as shown in table 8, are 85% in the Mechanical, the easiest and least scientific of the three major categories of invention, are rarest in the Chemical, and the subsequently assigned are intermediate between those assigned at issue and never.

[404]:

TABLE 8.—*Fields of patents, assigned and otherwise*

	Percents by class		
	Mechanical	Electrical	Chemical
"Never assigned" patents of 1938, 1948, and 1952	88.2	4.6	7.2
"Subsequently assigned" patents of 1938, 1948, and 1952	84.6	11.6	3.8
"Initially assigned" patents of 1938, 1948, and 1952	58.5	20.6	20.9
All patents of 1959	62.0	20.0	18.0

Source: Sanders, N 403.

[405] Two good indications of a patent's value are whether the invention is worked, and by how large a firm. Presumably the larger the firm the larger the working. Sanders' data on first reading yield the strange finding of the unassigned patents having been worked more than the assigned, viz., 64 vs. 58%.[404] But the score of the unassigned should be much lowered, by the consideration Sanders recognizes, that 76% of the nonassigning inventors did not respond, including probably a large proportion who felt humiliated or disgusted by the failure of their patent. On the assigned patents both patentee and assignee were questioned, and their replies were found generally congruent. Further considerations are that a lone inventor will not patent an invention unless he thinks, however misguidedly perhaps, that it may be a good one (including "nuisance" patents), whereas a great corporation may patent inventions it knows to be inferior and never intends to use, but would prevent others from possibly using. So the greatest companies never work 53.4% of their patents by present data, all companies 42.5%, but the small companies only 24.5%, if their 56.5% non-returns were to be ignored.[404]

[406] The—shall we guess 40%—of the "never assigned" patents which were ever worked, were doubtless worked on a very small scale, by the inventor himself. And so too, though somewhat more extensively, for the 3% assigned after issue, mostly to small companies. A patent worked by a vast auto or telephone company is usually quite another story, as to its economic significance.

[407] We have preferred the word "worked" patents rather than the usual patent term "used," both to follow literary English and to make a useful distinction. No patent is really *used* unless it is used to start and win an infringement suit, or to threaten one, or otherwise to deter or harrass an actual or potential rival, or to strengthen one's defense if sued. No statistics are possible on most of these uses. A patent can be *worked* without involving any of those uses, where no rivals are to be feared; but such a patent has little value, however useful the invention. And many patents are used without being worked, when they protect a better method, or fortify a monopoly. But after all, there is some correlation, some tendency for the working, use, and value of a patent to vary together, so that statistics of working can be one *index* of use and of value.

[408] The reasons given for the nonworking of patents, in Sanders' questionnaire, are of interest.[405] The inventors who have not assigned, name personal reasons for the nonworking, chiefly lack of venture capital, or neglect, in 57% of their responses, and reasons related to

the invention, the market's development, etc., in 43%. But the assigning patentees blame the nonworking on the personal factors in 19%, the impersonal in 81%; and the assignees report the proportions as 3 versus 97%. Again we see that the unorganized inventor not only makes the easier, smaller, poorer inventions, but commonly cannot put them over through personal incapacity.[406]

[409] Another means of comparing the assigning with the nonassigning patentees is afforded by Sanders' statistics on their respective educations.[97] He finds them much less schooled, with 12.3 grades completed on the average, versus 16 for those assigning patents. MacKinnon's [407] 14 independent inventors showed only 3 college graduates, 7 who only completed high school, 11 were sons of skilled tradesmen, only one was professional himself; and on the concept mastery test of intelligence they scored 51 versus 118 for inventive research scientists. Their ages averaged 47. An A. D. Little survey [394] that sought out 15 relatively successful amateur inventors, found their youngest to have 50 years, apparently a disappearing class. By Sanders' data the unassigning inventors averaged 46.3 years when receiving their patent, and the assigning ones 41.6 years:[408] and the proportion over 54 years at time of application was 23% versus 9.5%.[409]

[410] Yet the independent, basement inventor and the small firm are fair-haired boys of politics; they can do no wrong, and must be encouraged, say the prints of the marketplace. Indeed, Van Deusen, writing in *Fortune*,[204] says twice that the lone inventor should be defended by corporations, because if he is lost the patent system "may become defenseless against political attack." (What a confession of weakness in the system!) So he reviews some ways in which the free-lance might be or has been encouraged, as by adult university classes in the new technologies, inventor-aiding foundations, and more receptive, trusting, and cooperative attitudes from the corporate side. Yet his own statistics are devastating as to the value of outsiders' ideas.

[411] In fine, how shall we estimate the value of unorganized invention? We have seen that its products are smaller, easier, civil not military, mechanical rather than electrical or chemical, or else mere duplicable starts for inventions, which organization must essentially create. We have seen that the patents of the unorganized are almost always scorned, and when worked are produced on a smaller scale, a gadget perhaps. We must also consider Research in the appropriate sciences, and Development of even the smallest details (naturally carried through in connection with production); for all of these have been added in along with invention in the narrower sense, in our foregoing sections on invention's support by industry, governments, universities, trade associations, etc. With the university work already counted among the organized, and with little means by patents or any other institution whereby the unorganized inventor can be repaid for scientific research or for development, and with these two labors much more important in the organized sphere than invention in the narrowest, legally and economically patentable sense (cf. our ch. 6: Patents Do Not Apply to Most of Inventions), the following hypothesis seems to this writer reasonable: That considering ultimate values for invention produced, by all those kinds of research proper and development, there stands alongside each patent assigned to an American

corporation on issue, fifteen times as much contribution to invention and research, as stands beside each patent assigned after issue or never. If the reader is familiar with invention and thinks a different ratio would be juster, he can easily substitute his own. In any case, figuring that our patents are initially assigned 52.8% to domestic corporations while 39.3% go to individuals,[410] and dividing the latter percentage by 15 and applying it to the "funds supplied by industry" for 1954, we get the $110 million set down at the start of this section.

[412] A type of unorganized inventor quite different from the above discussed, is the man trying to start a new fundamental invention, where there is no established industry for it. This particularly neglected and needed type has been told of at length in chapter 8.

[413] 12. Awards and prizes:

Guessed stimulative value of awards about 1956----$0.4 million, 0.007%

We distinguish awards from prizes, considering that prizes are offered before the completion, for a specified invention to perform a certain function with a required degree of practicality. A notable example was the French Government offer in 1795 of 12,000 francs for a method of preserving food, won by Appert in 1809 with his inestimable invention of canning. Awards, on the other hand, far more common today, are given for inventions already made and successful, and may be bestowed through a regular system, or on occasion. Those falling under suggestion systems we treated under section 10. The motivation of both prizes and awards is almost always national or philanthropic, rather than commercial.

[414] Some amount of awards for invention and discovery in its related sciences has grown up through philanthropy, and recently through the Federal Government,[411] all reflected in table 9. In its top line, professional societies are the chief awarders, commonly administering special funds donated by philanthropists or corporations. The awards are usually honorary, including perhaps a gold medal, but 32% add cash;[412] and in this age when the alchemists are mostly on salary, honors are readily transmuted into gold, as well as being highly valued for their giving a sense of accomplishment and rank. It is very hard to put a money value on the honorary awards, and a further premium for the honorific value of the cash awards; but suppose we value the honorary awards at $1,000 each? This will give a valuation of $380,000, after removal of the Suggestions because duplicated in section 10.

TABLE 9.—*Awards to American inventors (and to some suggestors)*

Awarder	Year	Honorary	Cash awards	Total cash per year
Professional societies, etc.[412]	1955	168	78	$21,510
Nobel (Physics and Chemistry) [412]	1936–56 (average)		1	25,713
U.S. Civil Service Commission (suggestions) [413]	1959		97,802	2,807,698
AEC and NASA [414]			2	140,000?
Acts of Congress				25,000?
Total		168	97,883	3,019,921

[415] 13. Compulsory license: [415]

1938–57, yearly----$33 million, 0.58%.

This institution is explained in the corresponding section of the following chapter. For statistics we can only turn to the number of patents subjected by court order to compulsory license (and not free use), or else turn to Sanders' 123 responses from assignees who had licensed their patents of 1938, 1948, or 1952, to the question "What were the reasons for licensing it? (Comment)".[416] Of these licenses 4.9% were said to be granted because connected with a Government contract; and to these we shall add 2.9% for compulsory license.[417] The result is a percentage of all patents initially assigned to American corporations in those years, viz., 7.7%. We reported in ¶ 127 that in 1956 4.9% of the patents in nominal force were subject to compulsory license by court order. But most of these patents were not compulsorily licensed from their beginning, but by court order when largely run out; so this figure is consistent with that from ¶ 127. We should also consider as partially subject to compulsory license all inventions used or potentially usable by the Federal Government. What part the assigned patents represent of the total commercial inventive and research effort reckoned by the statistics (secs. 8 and 9), we have no good way of estimating. But following our guesses in ¶ 138,9 that about one-fifth of invention, etc., is patent-motivated, we would infer that about 1½% of it comes under compulsory license, sooner or later. In any case a status of compulsory licensing on demand is probably not a strong incentive for inventing or patenting, which would depend more on other motives; the compulsorily licensed patent, like some pooled patents, gives moderate royalties but not full freedom of ownership. So we are speaking in this section of a status, more than of a motive or support for invention.

[416] 14. Patent pooling and cross-licensing:

ca. 1957, percent of weighted patents	14.5%
1954, same percent of guessed patent-motivated, invention, etc	$305 million, 5.39%

Our two title phrases refer to the same idea in different degrees, patent pooling being more extensive as to number of patents and/or companies, than cross-licensing. One might consider here also patent consolidations or monopolies, where a dominating assemblage of patents are owned by one company; but we do not in the following statistics.[418]

[417] Once again we turn to the invaluable statistical studies of Sanders for quantification. If we may take the assigned patents as about all that matter, he found that 30% of them were licensed, and 39% of the licensing assignees gave "cross-licensing or a package deal" as their reason for licensing, to which we add 2.8% as before (see ft. N *417* below), making 41.8% of the licensed, or 14.5% for all assigned patents with responses. Some tendency was visible for an increase in the proportion licensing for that reason, between the patent years 1938 and 1952. We have set down 14.5% in the first statistical line at the head of this section, and in the line following have applied this percentage to the $2,880 million of the laboratories' contribution (sec. 9), diminished by one-fourth for their work not patent-motivated, in accordance with our guess in table 6, ¶ 138. There is probably some

[417] Of the licenses 5.7% were ascribed to "Compulsory licensing or interference." We shall assign half of these to Compulsory License, and the other half to our next sec. 14, Cross Licensing.

duplication between this section and the previous one, Compulsory Licensing.

[418] Again as above (sec. 13) we are dealing with a *status* of invention, more than with a motive for it, especially since the pooling and cross-licensing are largely due to court order or to manufacturing for the Government. But long before these Government pressures had become severe, patent pooling had become prevalent—the rule in many industries—notably the automobile, aircraft, electrical, and gasoline. Vaughan [254] listed 64 branches of manufacture that at one time or another have had patent pools, cross-licensing or patent monopolies, and to these we would add 36 others.[419]

[419] 15. Sale of know-how:

If 1¼% of secs. 9b and 11, then in 1953–54--$23 million, 0.41%

There can be no doubt that the sale of know-how, which could be called salable secrets plus often the training of personnel, is a large factor in manufacturing, especially in international deals, and that it is a considerable means of paying for inventions, both patented and otherwise. For the unpatented can be often protected by secrecy, (sec. 16) especially in chemical manufacturing, and by legal defenses if the purloiner broke a contract or a confidence [420] to take away information held secret. We have told (¶ 148, 164, 272–280) what delays and insufficient information may characterize patents, despite the law's requirement that they must set forth the best method known to the inventor at the time of his making application on the matters to be protected. The British *Economist* says that a company's know-how is frequently more valuable than the patents it holds; [421] the Russians are said to be often asking for American know-how, commonly refused them by American chemists; [421] Bergier [422] says that while the royalty for a patent is usually 2% of the turnover, for know-how, also, one would pay 8%. Among 180 companies questioned by the PTC Foundation [423] a majority said that know-how was much more important to them for foreign licensing, than patents or trademarks; and among 15 respondents who had made 1,215 foreign license agreements covering their know-how, patents and/or trademarks, know-how was included in 24%, and was the only thing sold in 3.2%. Our Government has made numerous arrangements with NATO powers for exchange of patents and information.[424] Sanders [425] found the assignees of worked patents considering know-how to be essential in about half the cases, with some rise apparent in the most recent patents, those of 1952, and rising in the sequence mechanical, electrical, chemical. There was also fair agreement between the questions of whether know-how was essential to the use of the patent, and whether the inventor devoted his attention to the development of know-how because of patent protection. On this last about 21% said yes, 19% indicated that patent protection was secondary or incidental, and 61% said it was of no moment.

[420] To assess the importance of the sale of know-how, in promoting invention, is of course very difficult; but we think again that

[419] Further pat. pools: Calcium chloride, can, cordage, electric strong current, electron tube, enameled sanitary ware, gas (illum.), geophysical prospecting, golf ball, gypsum wallboard, hardboard, hosiery (nonrun and ringless), hydrogenation, industrial furnaces, juke box, medical, mimeograph, oil cracking, dewaxing, and fractional distillation, oil burner, railway, refrigerator (elec.), salt, tabulating machines, talkie, tetraethyl lead, thermostat, tire (solid rubber), titania pigment, tobacco, trubenizing, typewriter, washing machine, wind stacker, and wiring devices.

even the shakiest "guesstimate" is better than *no* idea of quantity. Suppose we start with Sanders' finding,[425] that know-how was essential to half the assigned worked patents, and with our "guesstimate" that one-fifth of American inventing is motivated by patents (¶ 140). Then reflect that the know-how sold is not patented directly; indeed the elusive character of some techniques, depending on knack and trained perception rather than on clearly understood science, makes such arts unsuitable for patenting or for learning through publications, but largely possible to hold secret, and perhaps difficult to convey except through personal teaching of know-how. And as we said in ¶ 275, by the time the patentee comes to selling his invention, he has always learned more about how to work it, in its various forms and circumstances, than he knew and described in his application for patent. Patent pools (sec. 14) commonly trade know-how as well as patents. But on the other hand, much teaching of techniques is of old arts, not so bound up with new inventions as to amount to a sale of these. And there is the general opinion on sale of know-how, which rates it far below patent licensing in importance; and the fact that know-how does not deal with scientific discoveries which may lead to multiple inventions, but only with practical techniques. All in all, shall we rate the sale of know-how as motivating 1¼% of invention and invention-oriented research?

Part B: Transverse Categories of Invention's Support

[421] Having now determined, so well as we can, the contributions of the 15 hitherto numbered and defined sources of support for invention and its pertinent scientific research, we have set them down in table 7 (¶ 382), with their apparently productive outlays in column 3, their percentages of the net total in column 2, and in the remaining columns the repartition of the outlays between the wider categories Government, Business, and Philanthropy. This repartition is rough, omitting a category altogether where it seems unimportant in motivation, like patents in governments' and universities' work; and it is certainly often a very fallible guess. Our only justifications are that the totals and percents at the heads of the columns and rows, are more reliable than their constituent items, and are all that we ask any credence for; and once again, that some quantified idea of magnitude, though faulty, is better than none. All previous writers have described these magnitudes with only vague phrases, like "a large share", or "very little".

[422] In the first column, however, we yield before the difficulty of finding significant statistics to measure the role of Patents and Secrecy, and simply note their presence or absence in significant degree by an asterisk (*) or a dagger (†) respectively, with an ambiguous total provided in treating the pertinent sections 16 and 17. In the case of monopoly we cannot make any repartition that would not be obvious, but shall discuss the matter under section 18.

[423] 16. PATENTS.—Patents figure in most of our numbered supports for invention, as shown by the asterisks in column 1 of table 7, even after omitting supports in which patents are only of nominal importance. But how to reckon up their real importance as instigators we are at a loss to figure out. The items marked would add up to about 38% of the total, unduplicated financially.

[424] There are plenty of data on the *costs* of the patent system, but it is quite a question whether these costs are productive of invention, in the normally assumed dollar for dollar relation, or in some different ratio. From our ¶ 263 we calculated net yearly costs for operating the patent system at $16 million from the Government, and $124 million from commercial and other sources. These costs are not duplicated; the item of time and expenses of the scientific and executive staff anent patents were subtracted, being covered in section 9.

[425] 17. SECRECY.—We are considering commercial secrecy, not the more important military kind; and we must include pertinent secret scientific research as well as invention. Although lasting secrecy is impossible with most inventions, which are chiefly in the form, function, or formula of goods sold to others, yet secrecy remains decidedly important, now as in the past, in process inventions, chiefly chemical, and during the long task of developing any invention and manufacturing the first batches for the market, since the competitors' breaking and copying of the secrets, even if easy, will not be immediate. The head start thus given by secrecy, sealed by trademarks and good will, is probably an important factor paying for inventions, patented or not, as was mentioned in our earlier discussions of the subject (¶ 148, 164, 165, 272–280), where we showed secrecy to be not merely a substitute for patents, but also their regular accompaniment. The sale of know-how is also impossible without some degree of secrecy or at least reconditeness. And where secrecy is readily possible, a patent is of little use, since the patentee could hardly detect nor convict infringers.[254]

[426] Tuska [168] found 3 cases involving secrets out of 82 invention license cases important enough to have been sued on, with a yearly average yield from the secrets, of $12,000 per case.

[427] We have marked by daggers (†) in table 7, the invention sources where commercial secrecy plays a significant role, albeit always rivaled by the source named, as a means of paying for invention. The total percentage of the funds supporting invention and involving some secrecy is about 39%. The real importance of commercial secrecy the writer can only guess at—say 5%, with an equivalent reduction from other items, to bring the total back from 105% to 100%.

[428] 18. MONOPOLY AND BIG BUSINESS.—A full monopoly does not need patents, but an insecure monopoly may find them very convenient to buttress it, as we have said. (¶ 158, 159.) The monopoly that concerns us here is not the vast governmental monopolies, chiefly military, but commercial monopoly of an industry, or more to the point, of a product or method of production which has no good substitutes. Such monopoly is usually narrower than an industry (e.g., the kinescope for TV), but may be wider, permeating several industries, as with the transistor, and cryogenic inventions. Big business, too, does not need a patent to make large and profitable use of inventions and a laboratory, although a patent may be useful to hold up price and retain the whole market. Of the patents issued to corporations in 1939–55, 20.8% went to the 176 largest companies, which held an average of 1,200 apiece.[426]

[429] For lack of monopoly data on inventions, we can only turn to that on industries. Using his estimated repartition of the American workers between industries, Stigler [427] found those characterized

by Monopoly to be employing 20% in 1939, while Competition and Compulsory Cartels employed 80%, after eliminating 15% of a larger total as not allocable, 72% of this being Government. (Our chart 3 shows the magnitudes of organized commercial and Federal R&D at all dates.) Taking our year 1953–54 from table 7, ¶ 382, column 5 plus line 6, we read that the business motivation, this time taking in the tax benefit which it is free to use monopolistically or otherwise, contributes 52.1% of invention etc. Let us take 20% of this, making 10.4% for a rough guess as to the extent of private monopoly support for invention in our standard year. But this is quite unreliable, and incidentally would call for reducing other percentages by a corresponding amount. The share of monopoly would be somewhat less in the latest years due to the rise of Government inventing.

[430] Our one remaining mentioned institutional support for invention, viz., the miscellaneous services of government, often State and local, through libraries, museums, education, etc., is impossible to quantify for invention, and not necessary, since it operates only through the other institutions considered.

[431] In summary, first the share of government has become the greatest in the breeding of invention, say 61%, practically all Federal, without citing the miscellaneous ways in which government helps invention through education, libraries, postal subsidies, etc. The smaller, commercial sector, including the unorganized inventors, might be measured in various ways. As a controller of funds it might be rated at 52.1% (¶ 429). As an administrator of performance it might be rated as 69.7% of all.[428] But as a support of invention and research it seems to pay for only 37.2% (table 7, col. 5). And for fully competitive private industry we should figure something like 33%.[429] The philanthropic element comes to 1.4%. The minor supports, after setting aside the big two (the Federal Treasury and unduplicated organized industry) are all very minor, but still add up to about 9%. They should be possibly 17% larger with appropriate reduction of the big two, if we could have found figures for the research building funds of these sources, unversities, etc. Such additions to plant and equipment amounted to around that percentage [430] in the case of organized industry [390] and government.[369]

[432] Our brief, bald, and shaky statistics may seem a small reward for much belaboring of data; but since they are *more* explicit, detailed and sound measures than have ever been provided, for comparison of magnitudes most important when considering invention and the patent system, the author thinks them justifiable, as explained in ¶ 12.

Chapter 10

MERITS, DRAWBACKS AND BEST FIELDS OF THE VARIOUS INSTITUTIONS SUPPORTING INVENTION, WITH RECOMMENDATIONS

[433] Having in our previous chapter attempted to measure the recent and latest contributions of 18 institutions, to the support, and sometimes also the performance of invention, we shall now attempt some appraisal of their respective merits, and to state fields suitable to each, with some recommendations, and occasional notes on their historical developments. The same order and numbering will be used, except that No. 5, trade association inventing, will be left to chapter 11, and the patent system, and the unorganized inventor have been sufficiently covered already (chs. 2–7 and 9, secs. 11 and 16), save for our recommendations.

[434] But before one can do any appraising one must have a scale of values and a social philosophy by which to judge institutions. We take as an axiom that scientific progress and invention are vastly important and should be fostered to flourish far more in the future, for the redemption of mankind and the preservation and enhancement of our American culture. A second axiom is belief in the necessity of saving America from our communist enemies, and that this must be accomplished above all by military and economic strength, both vitally dependent on the progress of invention in America and in our allies. For economic growth, also, invention is most helpful. Another principle we proceed on is that it is best, so far as feasible, to operate within the free enterprise system, using governmental funds and particularly performance, only where commercial enterprise or philanthropic institutions like universities, cannot do the job acceptably. Another preference is for *competitive* free enterprise, rather than monopoly, unless the monopoly be regulated, as in the utilities. A final principle is that it is better to adapt existing institutions, rather than root them out and establish new and strange ones.

[435] Now, comparing the institutions supporting invention, in the order of the previous chapter, we consider first the greatest one:

1. FEDERAL FUNDS, supporting research and invention, worked out two-thirds of the time in commercial, university, or other outside laboratories. We found the Government paying for 54% of all in 1953–54, without counting the important tax and other governmental aids, nor following Solo's opinion that 30% of commercially supported R&D aims at Government work.[670] If we add only the tax-help it becomes 73%. The 1962 expenditure we estimate at $7.6 billion.[370]

[436] We see no reason to cut the governmental share, nor to enlarge it, except to aid invention and its appropriate research in other fields now left to commercial support but insufficiently served. Such fields are above all the civil fundamental inventions, discussed in chap-

ter 8, such as the desalting of water, which has been needed for centuries, achieved experimentally since ancient Greek times, but is only now being rapidly developed into its immense future destiny, as our and other governments and now even corporations enter the at last profitable area. The newly established Panel on Civilian Technology,[431] in the White House, has especially in view the encouragement of civil business application of inventions developed by the Government, usually for war, space, and atomic purposes, to the benefit of consumers and national productivity. Similar but more extensive proposals have recently been made by the Department of Commerce, for a Civilian Industrial Technology Program, to expand the work of universities, research institutions and *trade associations*, "toward solution of technical problems that are common to broad industrial sectors", says the Department. The dissemination of existing technic knowledge, the encouragement of its use, and the training of research workers would also be pursued. The example of free Europe is cited, as "devoting at least as much if not more total technic resources to civilian industrial needs than are we. In these European nations, the responsibility of the government to support financially and cooperatively the development of research basic to industry is recognized . . . . Our Government has long contributed support for technological progress in mining, fisheries, agriculture, and certain industrial segments (transportation for example), but has done very little to support broad technical activities in industry or to translate basic science into to technology vital to industry . . . . It is expected that the Government investment will be increased many times by the industries themselves."[667] The Department points out that 200 companies do 80% of the R&D, privately financed, a concentration too restrictive. The industries most needing help by the program are those that would most upbuild the national economy, and those that do the least inventing today; these are the most competitive, small-scale industries, such as textiles, construction, and metal working (¶ 546). A start in fiscal 1963 was approved by the Appropriations committees of both Houses, but failed to reach final vote; a budget of $7.4 million is presently requested for fiscal 1964. See further ¶ 567.5.

[437] Some other fields for invention seem so scantily provided for that they likewise need patronage either by the Federal Government, or by universities, foundations, or our proposed semipublic trade associations (ch. 11). Such fields and the places we have discussed them are Patent Office mechanization ¶ 105, with the creation of a new dialect, "Ruly English"; medical, surgical, agricultural, insecticidal, astronomical inventions, and science generally, already much cultivated by governments, etc. (¶ 223, 224); inventions for cities and States (¶ 225,6), for dealing with air and water pollution, waste disposal, sewerage, crime, prisons, traffic control, voting machines, tamper-proof records, educational devices, inventions not fully assessable upon their beneficiaries (¶ 222), such as insecticidal campaigns, conservation measures, or safety devices; and inventions and their needed scientific basis which could be brought into use only by the national authority changing or imposing a standard, notably in communication inventions, e.g., for mechanical handling of checks or letters (¶ 215), reading machines and alphabets for them (¶ 336); other custom-barred inventions (¶ 215); methods for indexing new things and people

(¶ 343); standardized transportation devices such as the combination of a special road with automatically guided autos (¶ 351); new trailer hitches, piggyback and truck-rail-ship arrangements (¶ 375); and standardized, universally reusable containers of many types and sizes. Finally, most suitable for Government would be the greatest goal of all, the supreme invention, the key to the key-rack—*improvement of the art of discovering and inventing* (¶ 457).

[438] In more general terms, and on the whole, things which can be sold to private users for their full social value were best invented by commercial industry and protected by patent if feasible. But where the buyers are the Government, or people whose individual benefits (at least by their own valuation) add up to less than the total social benefit, as with inventions to protect against pests, pollutions, sickness, accidents, ignorance, crime, military attack, or economic losses not imminent but distant (as with waste of natural resources); or for inventions calling for too long development for 17-year patents or other commercial incentives—or for scientific discovering without having to show in advance a likely early practical benefit from each line of inquiry—or for inventions which would need the authority of Government to change a standardization (mostly in communication and transportation)—or for inventions which would seem proper for the private inventors but which for some reason these have failed to provide us (like clear fused quartz, or a safe automobile lock)—in briefest words, for all those researches which society needs but which no firm can be well paid for making, here where private enterprise fails other institutions should be turned to, oftenest today the Federal Government, usually engaging commercial or university laboratories to do the finding, and sometimes allowing them patents on nongovernmental uses. The legislative history of governmental assistance is told in Study 22.[432]

[439] When Government supports invention it is almost always to achieve an envisaged purpose, usually in Defense; hence the research is organized according to this function, whether carried through in the Government's laboratory, or oftener farmed out. But there is another type of project which is started by an outside inventor or some group, and brought to the Government begging assistance; it may be a minor development or a great fundamental idea, the base for a new industry (ch. 8). Here it may find a *little* assistance from one U.S. bureau for all kinds of outsiders' inventive projects, the minor million-a-year Office of Technical Services told of in ¶ 383; or more important is the National Science Foundation, which allots to professors, etc., in physical, mathematical, and engineering fields 51% of its basic research funds, and budgets $263 million in all.[433] In Britain we find the National Research Development Corporation,[434] which now holds 3,000 patents and patent applications, more than one-third of them under active exploitation, their profits shared with the inventor. Among their inventions are *frozonic* milk which keeps flavor indefinitely, through ultrasonics and freezing, the Hovercraft, fuel cells, and long, floating bags to replace tanker barges. France has had since 1915 the Centre National de la Recherche Scientifique, covering all the sciences, with a budget of $29 million, of which $220,000 is for the Service des Inventions et Brevets. Thirty-one contracts were made with inventors, some sharing the profit from patents or sales of know-how, and 28

with users, in 1960.[435] We think that such Government assistance to inventor-initiators needs much expansion in America, particularly for the fundamental inventions and others that the patent system and commercialism cannot pay for. And yet we are aware of the very low quality, uselessness, and duplication of almost all outsider's projects that have not found commercial support, as set forth in ¶ 396–411.

[440] Logically, the whole world should join in paying for invention, since every country will gain from it, whether producing the new good, or consuming it, or both. It is not so much a matter of justice, as of economics, that the marginal payment for a benefit (the invention) should be just as large as the marginal profit from it, if demand and supply, the payment and the quantity produced, are to be in the most productive relationship, the ideal quantification. The most logical solution, a world treasury and administration to support noncommercial invention, may seem utopian and far in the future, but has been proposed for the UN [664] by many nations and various approaches to it have been already realized. The cooperation of the world's governments in the Geophysical Year 1957–58, especially in Antarctica, and in an international program of health research [665], the many international associations and multifarious comity of the "Republic of Science", various international languages, such as Esperanto (approved by UNESCO) and the written symbols of Mathematics, etc., are altogether of vast importance. Chairman Seaborg of the AEC has proposed joint action with Russia and other nations to build a huge synchrotron of 300 Bev., to explore the atom. The patent system is internationally coordinated, both by formal organization and informal imitation, but is hard to use internationally, requiring that the patents be translated, revised, paid for, and formally taken out, without delay, and then watched and defended, all separately, in each country where protection is sought. Duplicated searching of the prior art is an obvious waste, which France and the Low Countries and now the whole European Common Market, and the Scandinavian countries and Turkey, are seeking to end between them, through International Patent Offices (¶ 30).[436] The Director of the Canadian Patent Office long ago requested the cooperation of our own, which the JPOS endorsed (¶ 495). International documentation and translation services would help greatly, and our country is now leading the others of the intergovernmental patent organization in cooperative study of mechanical information retrieval.[437] Commissioner Ladd says that as the interdependence of the U.S. and Europe grows "it may very well be that . . . Europe and the U.S. . . . will consider seriously and decide to work for a common patent system." [437]

[441] Another great step forward, not too hard for great nations, would be an international science library, of books, references, and experts, of unparalleled extent and organization, using Esperanto as a very easy and neutral common language, but with at least the reference files duplicated in all the world's great cities, by microfilm or otherwise. With such a magnificent tool, the inventor or scientist could find easily, promptly and in a language he could read, everything that had ever been published, or left in nonsecret manuscript, anywhere in the world, on any particular point he needed. The help to invention and science would be great, and world fellowship would be furthered.

[442] Finally, our Government has made elaborate arrangements for the exchange of patent rights and technical information for defense purposes with our allies in NATO, ANZUS, and Japan.[424] But these arrangements support invention only through patents under compulsory license and through sale of know-how, supports for the transmission more than for the origination of military inventions.

[443] Further fields for Federal decision and improvement are for the best ways to get military inventions into civil use (¶ 436 & 521), and all other patent questions (¶ 485–522).

[444] 2. STATE GOVERNMENTS. Their very small share in invention and its researches, aside from their support of universities, etc., 0.2%, seems hardly appropriate to enlarge, since there are no problems whose solution is needed by only one State. This is even more true for the States' subdivisions, the cities and counties. None of them have any inclination nor capacity to use the patent system to recoup their outlays from others' use.

[445] 3. UNIVERSITIES and colleges, proper, are something like 16 times as important in the dollar measure of their *performance*, as in their direct support of invention and its pertinent scientific researches, where we find them contributing only a half percent. Admittedly, of course, they perform invaluable functions of scientific education, library service, publication, propaganda for science, foreign contacts, providing a favorable *milieu* for associated institutes and commercial laboratories, and cultivating sciences often contributing to invention, including the biological, agricultural, geologic, legal, and social; this book could not have been written without the last.

[446] We see little hope nor need for increasing the universities' small cash contribution to invention and its researches. Palmer [160] would have them expand their inventive work, which employed 2,136 engineers and scientists,[384] and their patenting (¶ 452); Melman, [438] on the contrary, argues at length that the abundant research now done by the universities on public and commercial contracts perverts the professors, students, and whole spirit of the university, from education and the pursuit of science for its own sake, to the goal of money-making for the firm, university, faculty, and even professor, and to secrecy in lieu of generous illumination of all. To the writer it seems that the proper functions for a university are not just teaching and such researches as no one else will pay for, but should include functions indefinitely numerous, such as serving national defense, political leadership, sick people, faculty children, providing wayward youth a safe home and recreations—any work that seems convenient and worth its cost, while ever recognizing that to do also B usually robs a part of A.

[447] 4. PROFESSIONAL SOCIETIES. The dues-collecting basis of these societies bars them from any large financial contribution to invention or science; but the vast competence which they enfold would seem to fit them for administering larger funds contributed by others, as they do in allotting most of the awards (sec. 12). Usually lacking laboratories, their performance is only two-fifths of their tiny contribution.[377] Other helps they render researchers are recognition, appraisal, contacts (including international), publication, and standardizations of language, units, and devices.

[448] 5. TRADE ASSOCIATIONS. Here again we meet completest competence yet insignificant funds, a quarter percent of all for

invention and research. But so important is their possibility of development that we shall devote our chapter 11 to it, and cite also Study 21 [378] on the associations' present inventive work.

[449] 6. TAX BENEFITS. This enormous aid to invention and research amounts to about 19% of its whole support, simply through nontaxation of corporate profits invested in R&D, without counting the numerous further tax benefits listed in ¶ 390. The corporate tax exemption on invention has the questionable advantage that it leaves the conduct of the research and all decisions on what to essay, solely in the hands of any corporation which chooses to so invest earned money instead of putting 48% of it into dividends or other investments, and paying 52% in corporate income tax. Under *laissez-faire* principles a corporation might be assumed to know better than a government, what to do with its money. But liberal thought sees many occasions where this is not true, e.g., when national purposes demand more invention in certain fields; and indeed every tax is contrary to that principle. Furthermore, by well established economic law that whatever is subsidized or made cheaper becomes thereby enlarged—*if* the enterprisers left to themselves would allot just the right amount to invention, then when the tax exemption lets them buy a dollar's worth of research for 48 cents, they would buy too much of it.

[450] The matter is one calling for the profoundest consideration of national needs and present accomplishment of research, as the National Science Foundation says.[439] We may contribute here just one suggestion. This is that the powerful and fiscally expensive aid of tax exemption might be used with more discrimination. At present the only distinctions made are between large and small corporate and private inventors, and the latter's patron, and between a corporation's current expense for R&D and its capital expenditures for equipping the same (¶ 390). These distinctions, whatever their motives, are not very pertinent from the viewpoint of fostering invention for national welfare. More logical would be distinctions based on the probable social value of the inventions to be produced. One laboratory is researching to promote health, or national defense, another to increase the salability of cigarettes, liquor, pinball machines or advertisements; all alike are tax exempt. Yet, when we impose instead of excusing taxes, we discriminate: tobacco, liquor, gambling, amusements, and luxuries are struck with heavy special taxes, partly on purpose to reduce their share in the national life. Tax distinctions might also be made between basic and applied research,[440] or according to the efficiency, or probability of success, of the type of laboratory or freelance inventor, according to past experience. An annual $2 billion gift, or exemption, does not seem a trifle to be granted with so little thought, and so little pertinent discrimination as to who shall get it.

[451] 7. FOUNDATIONS. The idea of a special institution to make or aid inventions or discoveries is a logical and old idea. It was proposed in 1574,[441] and also by Francis Bacon, realized in a very small way by the French Academy in 1668, and in America by the Research Corporation, N.Y., 1912, Mellon Institute in Pittsburgh, 1913, Battelle in Columbus, 1929, now the world's largest, Armour in Chicago, 1936,

[440] Basic research was 8.5% of all in 1953 & 1954, 8% in 1959. From *Reviews of Data*. N 40, table 1.

and a number of others especially since 1940, in various parts of the country.[384] Since they have been described in Government publications of the present series [442] and elsewhere,[384, 385] we need say here only that while they differ somewhat, in general their founding and purposes are philanthropic, they are sometimes affiliated with a university, and their current support comes almost wholly from the corporations (one-third of it) and Government (two-thirds) for which they do research jobs.[384] They often use patents, assigned to the sponsoring corporation, and even secrecy. Yet they favor basic research, amounting to 33% of their inventive work.[383] Their commercial motivation is in some cases so strong that proposals have been made to limit their tax exemption.

[452] The Research Corporation, a quite special type, was founded by Prof. Frederick G. Cottrell with his patents for endowment, on electric precipitation, along with the sound idea that patents are a commercial institution which can produce important profits only when managed in an aggressive commercial (competitive or monopolistic) manner. It is necessary to keep working on one's important inventions, and patenting improvements, to retain one's lead over competitors, and one must also fight for rights, and keep an eye always open for profits, and closed to the feelings of a fellow professor with an invention, and a little closed to the welfare of science and people generally, when that would interfere with profits. So 112 institutions, mostly universities, turn over their patents to this corporation,[443] which held 456 American and 277 foreign patents in 1952, and 238 applications, and which distributes the net profits from them, usually 10–15% to the personal inventors, and splits the rest equally with the proffering institution; thus the universities received half a million dollars in 1960.[444] In addition the corporation gives awards for past successes, and makes grants to individuals and universities to support promising researches and inventions, 288 of them about 1951.[445] From these have sprung some notable triumphs in the past: Lawrence's cyclotron, the Van de Graaf-Trump accelerator, and Kendall's steps toward cortisone. Finally the corporation runs a factory of its own, with 1,000 employees.

[453] As for recommendations, the philanthropic basis of the foundations, and their meager support hitherto, except by payment for jobs done at others' behest, may make any recommendations [446] rather useless. But still one would think that further advantage might be drawn from the unique independence and plurality of the foundations, to support inventions and researches which no one else will, because their benefits are remote, or inure to the public rather than to firms or the Government, or because the proponent is an impractical person, or simply because his idea is too new and strange for anyone but an occasional scholar to see its merit. E.g., the sometime Inventors Foundation [447] gave courses for inventors, on patenting and commercialization, and help in working out their problems. The Research Foundation and others, too, have helped inventors, as we said. Our consideration of the freelance and amateur inventor in section 11 of the previous chapter indicates a strong call for helping them, but that we cannot hope for any big inventive contribution from them—minor inventions and a few seminal ideas rather than long and costly working out.

[454] 9. ORGANIZED INDUSTRY. We have found this second most important source supporting but 16% of invention and its researches, through the patent system and simple commercial motives for technical improvement, after eliminating its use of patent pooling, compulsory license, know-how sales and tax benefits; but it *performs* 72% of the inventing and discovering, and pays for 48% of it, in one way or another.

[455] The typical instrument for reimbursement of Organized Industry is the patent system; but this by no means pays for all of Industry's inventive program. Much the larger part is paid for by the other institutions listed, including Secrecy, usually temporary, and Monopoly—or by trademarks, advertising and good will protecting a product after its secrecy and perhaps patent have run out, and by the enlargement of one's industry although including one's competitors, through a better product or cheaper production, since each industry competes with others for the consumers' or Government's dollar.

[456] It may be rather useless and even contrary to the spirit of private enterprise to point out areas of invention and research which such enterprise has left unattended because they have seemed unprofitable to the firm, and ask them to divert their money thither. Yet such areas are very numerous, covering a majority of the needs, as we point out in chapter 6, what with the scientific, the unpatentable, military, long-range, remote, very risky, the nonassessable upon the beneficiaries, and the custom-barred. We were best simply to invite into these vast areas the governmental and other nonprofit institutions that seem most suitable for each field, above all the proposed invigorated trade associations (ch. 11). Paragraph 458 suggests better handling of outsiders' proposals, and chapter 13 those of their inventive employees.

[457] 10. SUGGESTION SYSTEMS. On this institution for the humblest inventing (¶ 94, 138, 395), accounting for something less than 1% of invention and research, the author has no recommendations. But compare ¶ 460, 462.

[458] 11. UNORGANIZED INVENTORS. We have considered at length (¶ 396–411) the almost invariable failure of the outsider when attempting invention, the limited working of his and the small firm's patents when successful, and the small-fry's practical absence from such fields of science as lead to invention. The scientists organized in universities, foundations, laboratories, etc., are counted not here but elsewhere, if working at their job; if acting independently they should be counted here. While we guessed the contribution of the unorganized inventors to be small, only 2½%, still something might be done to improve their situation, as we implied in ¶ 400. The wasted effort by incompetent outsiders might be reduced by less propaganda from the patent law profession, popular magazines, and National Inventors Council, inviting common men to invent outside their special competence. Some propaganda material featuring inventions like Howe's sewing machine, from an age that is past and gone, might be cited. On the positive side, more help might be given with probable profit to some would-be inventors with military or commercial ideas they strongly believe in, especially when the invention, or line of scientific research, has a potential value that would be large, for the Nation, but of smaller appeal to any commercial or military authority.

Such inventions we have discussed in chapter 6. Especially worthy might be a scarcely patentable or unpatentable invention for State or local government, say in education, the architecture of prisons or institutions, crime prevention, fire fighting, sewerage, or coping with pollution of air or water, and all inventions and reseaches for enabling *consumers* not merely to be protected in their health, but economically, to get the most for their money, e.g. by a microfilmed encyclopedia (¶ 337), and to get the best for their special needs, and such goods as can be repaired, altered, or easily resold, instead of being thrown away and a new one bought, as may be to the manufacturer's but not the public's interest. Such assistance to reseachers is now given very extensively by universities and foundations (counted), and a small million dollars' worth by the Office of Technical Services (¶ 383); the trade associations would help many, though not all types if they had the funds. Research, or science, is much better taken care of in noncommercial ways than is invention; for we have been learning for several centuries past that science is indispensable, and cannot pay its own bills; but invention proper is still usually thought to be taken care of by commercialism and the patent system, unless military (ch. 8).

[459] 12. PRIZES AND AWARDS. PRIZES, offered to call forth an invention with specified traits and efficiency, like the prizes that called forth canning, the chronometer, and some early aircraft, have practically dropped out of use, because they do not seem adapted to the fast developments, high expenses, and needed team, laboratory, and highly informed attack, which characterize the important inventions wanted today. Yet they might sometimes be helpful.

[460] AWARDS,[411] granted after the inventions or discoveries have proved themselves, have been known for a century or more, and seem to be increasing nowadays. Whether or not including a modest reward of cash, as one-third do, and in Russia valued privileges, they always provide a large measure of honor, rank, the esteem of those friends and colleagues whose good opinion we most long for, the strongest motivation in life above the biological level of food, sex, and safety. Furthermore, as we said (¶ 414), in a salaried age honors are readily transmuted into raises, which in turn spell further rank. Awards are almost always granted to individuals rather than to the teams, companies, or institutions which might perhaps better be called the discoverers. Perhaps the reason is that an honor, and maybe some dollars, mean more to a man than to any group.

[461] We have found awards[448] the smallest of all our factors, perhaps from too money-bound a method of reckoning. We and others[449] think the institution should be expanded, with more funds, governmental decorations, titles, and privileges, for the best, awarded perhaps some by a foundation or a governmental agency, though usually best distributed by the professional societies, as today, since honor from one's confreres means more than from any other group.

[462] Awards, and their humble brother Suggestion Systems, have the merit of bypassing all rules of eligibility, except their own; theirs are always more or less restrictive, but on different bases from other rules; so the inventor or scientist who did great work, but failed for any reason to benefit sufficiently from a patent, commercial profits, or salary, has a chance of reward through awards or suggestion systems. However useful, these institutions could never become the main sup-

port of invention, because they are for individuals, not laboratory teams, and because they pay *after* victory is won, instead of long before, when the support is most needed.

[463] 13. COMPULSORY LICENSE of patents, which we found to be back of something less than 1% of American invention and research, is an institution essentially different from the patent system, though it employs patents. It does not grant exclusive control to the patentee, and it determines the price and other terms by Government action, in default of private agreement. It is generally advocated by liberals who are outsiders to patenting, and opposed by conservatives and insiders. Its legislative history has been told in the 12th study [415] of the present series, a long history of proposed legislation, always defeated in its proposals to allow private firms to sue for a license. But recently we have seen wholesale grantings of such license by courts in antitrust judgments, as detailed in other reports,[450] and with recent legislation that any invention wanted by the Federal Government, or relating to atomic energy, be subject to compulsory license. Court orders for free licensing, in effect canceling the patents, and compulsory license decrees affecting future as well as present patents, are particularly objected to, as discouraging invention.[451]

[464] Compulsory license laws and proposals are quite various, and always restricted in application. By international custom and regulation licensing may not be imposed upon a foreign patentee until at least 3 years after issue. Some firm must usually demand a license, on the basis of some allowed reason, usually that the patent is not currently worked sufficiently in the complainant's country, or prevents economic use of another patent, or has been misused monopolistically, or lies in certain fields, such as all food and drug patents in some countries, or atomic energy or Government need in the U.S. These last and monopolistic misuses are the only grounds here. What court or Government office will judge these issues and determine the royalty rate and the licensee(s), and reopen its decision from time to time as business conditions change, and who will sue infringers, and on what principles all these acts shall be decided and quantified, are other problems variously met and to be met.

[465] To decide what should be the policy of the U.S., among all these possibilities, aspects, and details, is a problem of extraordinary difficulty, which Congress has been wrestling with for half a century, without reaching any decisions of importance except as to Government-wanted patents, while the courts have proceeded in shaping up their own law for the attack on monopoly. To plan or to reject such a law is beyond the competence of the present writer; but he thinks the following observations to be sound and useful.

[466] Compulsory license by general rule, of patents deemed misused or unsuitable for private monopoly, is in the statutes of every industrial nation save the U.S.[452] and has been for many years. So there is a vast fund of experience available, assembled by Neumeyer, Federico, and others,[453] on which we ought chiefly to base any American legislation along such lines, even though some allowance must be made for differing legal and customary conditions in the various countries. The chief upshot of all this experience is simply: *compul-*

[452] We include France, which has a law also found in many countries, but losing favor and scarcely enforced, for Revocation of unworked patents.

sory licensing is scarcely used. At least there is practically never in any country,[454] an application for it that succeeds through official action. In England, e.g., there were 5 successful applications in 20 years.[455] Various students have argued that the law can be effective without enforcements, through patentees obeying its spirit and granting licenses on acceptable terms; but it is hard for the present writer to believe that any law inherently difficult to enforce can be effective if it is practically never enforced. If people act properly it is probably from other motives than fear of a scarcely enforced law.

[467] *Why* is this law, almost everywhere approved, almost never enforced? Simply because it requires too heavy a burden of proof from the complainant. He must be, in the usual case, a manufacturer able and anxious to work a patent, which has remained unworked, or little worked, in his country, or which has been used oppressively, or licensed at too high a price. These claims he must prove; but most of the facts are hid under the hat of his opponent—what the invention is really worth, what plans the owner has for working it, or how much it is worked, or how much if at all the country suffers through importing instead of making it. Furthermore, the complainant must counter the tradition that a patent is property, which its owner is entitled to keep. As Lincoln said, "Possession is 9 points (9/12) of the law." The burden upon the complainant is simply too great. Furthermore, very few are eligible to complain; there are other means to enter that production, e.g., by a consented license; there are other fields to turn to; and that patent is only one of countless things needed to enter a line successfully. One may need other firms' patents too, costly development, know-how, the trademark, goodwill, experience, lower royalties, more capital, alliances, what not.

[468] This much is the clear teaching of the rest of the world's experience: now to apply it to America. Here we are still more devoted to legalism, our litigation is more expensive, our *laissez-faire* tradition of capitalist liberty is stronger, our liking for bureaucratic administration less—so one may expect that the usual compulsory licensing would fail here still worse than elsewhere. It would remain a dead letter, a mere complication of the statutes, often thought of, rarely heeded, and practically never successfully invoked.

[469] But this is not to say that *another kind* of compulsory licensing law, one that would greatly ease the burden on the complainant, might not succeed here. Indeed, the kind our courts invented, compulsory licensing as an abatement and punishment for industrial monopoly, imposed by a Federal court in an antitrust action usually brought by the Government, has become decidely important, probably more so than all the compulsory license laws in any foreign country. *Business Week*, reviewing the Senate study,[456] found compulsory licensing involved in 81 of 107 cases between 1941 and 1956; in 31 no patent license was issued, and in most cases few, but in some cases the resultant licenses were numerous and important. The conclusion was that where an industry has been dominated by one company, compulsory license is not a substitute for dissolving the monopoly.

[470] It is quite possible, for aught this writer knows, that a general compulsory license law aimed at various "evils" complained of in various countries, might succeed in America, if the suits were filed, fought through, and from time to time reopened for readjustment not

by individual complainants but by a large and vigorous Federal bureau, like or part of the Federal commissions that now administer trade, interstate commerce, communications, pure food, etc. Before the institution of these commissions and regulatory departments we used to rely on private suits to correct abuses; but their effect was feeble and found insufficient. The Patent Office would have to be much altered to take on such a function, since its whole tradition is simply to grant a patent to every applicant, unless a technical anticipation can be found, ignoring questions of economics and public welfare. R. L. Meier, like various students,[457] proposes that after 5 years of nonworking, any such patent be opened to anyone's use, with the patentee free to sue for royalties, to be set by the court. Thus the burden of proof would be shifted from the complaining outsider to the patentee, and the free initiative, to use any idea one could find or think up, which a patentee had enjoyed for more than 5 years but had not carried through to working, would be transferred to anyone else who thought he could use the published idea. But the proposal does not fully meet the cases of justifiable nonworking, nor the very numerous inventions which need concentration or monopoly of development and manufacture. Neither would the Kefauver bill,[230] which after 3 years from date of patent application would grant an unrestricted license to every qualified drug manufacturer applying, with a ceiling fee of 8% of the licensee's selling price. The various abuses uncovered in the drug industry, reflected in highest profits, and 24% of the sales dollar going to competitive sales promotion, may well justify such a strong remedy. The Department of Health, Education, and Welfare has already set up such a compulsory license system in place of former free public use, and found it demanded by the mental drug manufacturers.[458] The recommendation of the National Patent Planning Commission [459] would allow court discretion as to whether the patent monopoly should be sustained against infringers, or compulsory license granted, in fields of defense, health, and safety.

[471] We have spoken of "evils" attacked by various compulsory license laws: we may need to ask whether some of them *are* evil. The mutual interference of basic and improvement patents we may safely call such. Monopoly is often not an evil, in industries of high first costs, like the public utilities and many hard goods manufacturing industries, that have high costs of tooling up, to turn out a moderate number of identical devices. So the British law provides that a compulsory license may be exclusive, even against the patentee. Where competition should be provided, a question remains of *how much* competition we want, whether unlimited or by just a few firms, lest the scale of working become too small. The maintenance of quality, especially in drugs, may be a sound motive for monopoly. Good behavior, maximum production, by a monopoly, may speak against attacking it.

[472] Nonworking of a patent may be no evil but a useful correction of the patent system, as we said anent the usually misrepresented suppression of inventions (¶ 304–319). An unworked patent must be on the average of small importance, and seems at first glance a mere nuisance, especially if someone wants to work it. But if the owner refuses to license it he must have a reason, such as owning a better way, and this would need be inquired into by bureaucrats seeking the

public welfare, not be overruled automatically. The "evil" of working an invention abroad but not in one's own country, often attacked by compulsory license laws, is nothing but an expression of protectionism (¶ 174), autarchy, which an economist cannot approve, except for cases that might come under starting an "infant industry" that would later become able to compete, or for needed military self-sufficiency.

[473] The evil of conflicting patents, often attacked by compulsory license laws, is a real and serious one. It commonly occurs where one patentee holds a basic patent, while others have made later improvements on it, or hold other, perhaps earlier patents that could most effectively be worked along with it. Neither party can work at full efficiency, nor perhaps work at all, without the other's license. Each can hold up the other, there is no market price for guidance, the situation is a tough one, as we said in ¶ 281–3, an actionable degree of interference can hardly be defined by a compulsory license law, and the situation is most often resolved in America, if painfully, by mutual cross-licensing or a patent pool. A compulsory license law could perhaps help here. A complainant would not have to prove anything about the defendant's business, but would still have to go into court to take some of his property away from him, giving in return a royalty (determined how?) and a cross-license on his own patent(s), which might be of little value. Dr. Bush proposes such a law.[460] Thorougher solutions, and cheaper in proportion to their usefulness, might be a mutual cross-licensing of all patents between two firms, or a wider patent pool for the industry, or our still wider trade association patent pool system (chap. 11).

[474] Compulsory licensing is sometimes advocated as a means to enable little companies to beard the big, forcing entrance into a monopolized industry by extracting a patent license from them. But others say that compulsory licensing would most hurt the independent inventors, who have no resources but their patent to fight with [232]—the big fellows would take away their patent for a small royalty.

[475] Writers on compulsory licensing seem to take for granted that the royalties ordered by it are rather meager, so that the compulsory licensing system directly lessens the reward for inventing. It seems to have decreased patenting by the companies affected at least 20%.[461] To be sure, it might conceivably enhance patents' value, if it stimulated competition, industry, and invention through enlarging the applicability of all inventions. But though it be established custom, we see no necessity that the royalties be small, if they were allotted and from time to time adjusted by an expert and vigorous bureaucracy. But of course the higher the royalty, the more it will discourage the use of the invention (¶ 253–7), and encourage evasion. We see no possibility of a simple rule, such as the market price of the patent, or a percentage of the price of the article, or of the saving made, which could efficiently determine the charge without judicial or bureaucratic discretion.

[476] "Licenses of Right" may be mentioned here, as a variety of compulsory licensing. The phrase refers to patents listed as open to license, on terms to be fixed by Government failing agreement between the parties, having got on this list either by purpose-category or by administrative or court order (compulsory licensing), or by the patentee's choice. The U.S. published such a list in 1952 and 1963, when

there were about 66,000 patents listed. In England and Germany, Licenses of Right, about 5% of all, are applied for voluntarily, for half-fees, and with the likelihood that the invention will be considered of small value.[462]

[477] To sum up on compulsory licensing, the half century of congressional study of its adoption along conventional lines should be terminated by consulting the experience of all other countries. This shows unanimously that even if commendable in aim, such compulsory licensing is practically unused in fact, and would not be worth its inches in the statute book. But new types of compulsory licensing, the court-imposed antitrust penalty, or vigorous administration by a commission, or some other way escaping dependence on plaintiffs' plaintive suits, might well be studied. In any case the substitute institutions are patent cross-licensing and pooling, trade association inventing, Government helps for invention, and against monopoly all the familiar deterrents.

[478] 14. PATENT POOLING AND CROSS-LICENSING, which we found prevailing in about 13% of the patents and 4½% of R&D, began in America with the combination of manufacturers of the Howe and Singer sewing machines, about 1860.[463] Along with court-imposed compulsory licensing, it has come to be the status, if *not* the principal motivation, of a large part of our valuable patented invention. Yet it has often been attacked as a breeder of monopoly, notably by Vaughan.[254] As an economist of invention he should have known better, but he had an obsession against monopoly.

[479] We have a proverb, whose trace of profanity is impossible to expurgate: "That's a helluva way to run a railroad." Suppose when some court is reorganizing a bankrupt railroad, the court should divide the engineering department between several independent corporations, each of which was given the right to hamper or stop entirely the operations of the road, until its demands were met, demands for the largest share of the profits that might hopefully be extracted by this veto tactic. And this game of mutual holdup to be practiced not just once, but habitually. What way would that be to run a railroad? Why, the patent way, like the good old patent system, invented in 1474, which gives the owner of each improvement the right to forbid any use of it for 17 years, unless his demands are met. It survives because we have learned several ways to abate it, one of which is patent pooling. Just as the railroads would bankrupt each other if they practiced free competition, as every economist knows, and as the ICC recognizes by setting minimum rates, so business, particularly big business, has learned to abate the patent system's root defect of the veto on use of one's invention, by various evolved devices. One is patent pooling or cross-licensing, one is comity, or decent modesty in demands, one is getting power over the patentee by any devices of pressure, legal attack, or purchase, and one is compulsory licensing, imposed by our Federal courts.

[480] Howard,[464] reviewing the efforts of our Government, sometimes to create patent pools, but after each major step forward in petroleum technology suing to destroy the adopted pool, said that patent policy should be based on live and let live, not on kill or be killed. He thought a permanent Government conciliation service in the Antitrust Division might be the solution, just as labor conciliation has become an essential part of our labor machinery.

[481] But let us leave further discussion of patent pooling to the following chapter, wherein we shall propose a new means for greatly encouraging it.

[482] 15. KNOW-HOW SALES, and 17. SECRECY. The latter we scarcely attempted to measure; the former we estimated at a half of 1%, in the payment and motivation of R&D. This teaching of a new art, patented or not, with sometimes the training of personnel, is a sort of unofficial patent system, which has grown up as a supplement for it, and for the oldtime training of apprentices, and migration of key craftsmen. The law [465] has previously tended to regard know-how, whether sold, stolen, or kept close, as a private matter with which law is unconcerned, except where there occurred a breach of promise, as by a trusted employee going to work for a competitor in defiance of a fair contract he had made,[420] or through a breach of confidence. But in recent years the law has sometimes recognized that impartible know-how, about the same thing as trade secrets, is a kind of private patent, and hence should be subject to laws like those of compulsory licensing. Indeed, the know-how often includes a possibly illegal, secret annex to a patent, necessary to make it really workable and perhaps known to the inventor at the time of patent application, yet omitted from this. So in Britain [421] and America in wartime, firms possessing needed secrets have been ordered to impart them to rival firms needing them on munitions contracts. And in American antitrust court decrees compulsory licensing "is usually accompanied by other positive measures, such as the obligation to furnish necessary unpatented 'know-how' and to provide licensees with the assistance of engineering experts." [466] The National Association of Manufacturers has recommended that where the Government forces transfer of trade secrets it should award compensation.[467]

[483] All these measures seem justified and meriting further extension, if we look at trade secrets and know-how as kinds of private patent protection, and note that they differ from public patents in four respects: (1) They may be more extensive and important, extending to the smallest details and to diverse parts of an art. (2) They are kept secret and restricted in use instead of being published to the world as a patent is when issued. (3) In some cases they continue their secrecy and restriction for more than 17 years, even though most patents and secrets lose value before then. (4) If a secret discovery or invention, say a commercial analysis of a problem and proposals for meeting it, never comes into use, as is true of 40% of patents (¶ 116), there is no way provided by which the world will ever be instructed. Yet the secrets doubtless contain useful findings, even if only negative ones, that something could *not* be done. Patent applications dropped for any reason, about 38% of all, are likewise filed in "Limbo," the cave of perpetual secrecy.

[484] These four considerations point up that secrecy is a great evil, one which the patent system is always praised for combating (despite its frequent sharing in the same evil (¶ 272–280). Measures are called for to reduce secrecy and get the best know-how quickly spread to all who need it. This is true despite the counterposed fact that secrecy and the sale of know-how serve also the useful purpose of partly paying for some of research and invention. If this present

system is unavoidable, then the good in it is to be subtracted from the bad, or vice versa, whichever is less; but if we could by other arrangements, such as our plan of the next chapter, and by present noncommercial R&D, separate and get rid of the bad (secrecy), without loss of the good (invention), we should be much better off. Granting patents with less than the present average delay of 3 or 4 years (¶ 301) would reduce one great form of secrecy, and so would the 20-year law (¶ 302), and measures for opening applications too long pending. And if we wished, less legal protection for trade secrets. But best of all, trade association organization (ch. 11).

[485] 16. PATENTS. This factor for invention and research we were likewise unable to measure, so fall back on our variously illumined "guesstimate" that very likely patents are a serious factor in about one-fifth of invention, R&D. As to the history, merits, shortcomings, and best fields for the patent system we have already said much in chapters 2, 5–7 and in sections 9, 11, and 16 of chapter 9, and elsewhere. In the present chapter we should only gather together and cross-reference recommendations and suggestions for the improvement of the patent system. And this the present writer ought to do most cautiously, passing along suggestions rather than passing upon their merits, because there are thousands who have more professional acquaintance and detailed knowledge of the patent system and its proposed reforms, than he.

[486] But yet there is need here for an outsider having some acquaintance with the system, and a lifelong concern about it. In the inventional history of the ship it was noted that though the great bulk of her improvements were made by insiders, her revolutionary changes like steam propulsion were due to outsiders, who yet knew their footing on water, and in other needed realms. "The professional devotees of the ancient, well-loved, and piously reverenced ship are forever perfecting her, but had as lief capsize her as turn her upside down." [468] Joseph Bailey Brown, an honored patent attorney, notes that institutions do not reform themselves voluntarily, but by compulsion from outsiders, as in the reforms of banking, stock exchanges, oil and gas conservation, and criminal law and jury procedure.[469] Patent litigation has become a game, he says, and "the better the player, the more complicated and uncertain he likes the game to be, and the more likely the result is to be a triumph of the skill of counsel, rather than a determination of the real merit of the patent or the defenses." E.g., his skill in choosing the best circuit to appeal in, would be wasted should a single appeals court be established.[470]

[487] Perceiving this professional bias toward the old game, the Senate's antitrust patent hearings of 1942 called no patent attorney nor Commissioner Coe.[471] And President Franklin D. Roosevelt when he created the National Patent Planning Commission to reconsider

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[470] C. W. Rivise said: "Inventors and technical men, who should really take the initiative in demanding that Congress make the necessary changes in our laws, have always been inclined to leave the matter in the hands of the lawyers. The lawyers, on the other hand, appear to be the greatest enemies of improvement, not alone in our patent system but in all our other legal institutions as well. . . . The only hope for a thorough overhauling of the patent system and correction of its defects and abuses lies in the forcing of action by men outside the legal profession." The trade associations could help here, he said, and patent pooling. Tech. Asns. & the Pat. Situation; *Paper Trade J.* 96:33–5, Jan. 26, 1933, p. 35.

Fortune tells how 50 patent bills had recently died in committee or under "attack of a patent bar that had acquired a vested interest in chaos." N 234.

the whole system, appointed to it not one patent lawyer nor other inside professional. But what did his appointees do? They followed the immemorial rule: To become informed on a business, ask an expert within it. That rule almost always serves us well; but it cannot be expected to give us basic criticism nor a new view of a business. They straightaway chose for their Secretary the Commissioner of Patents, the conservative Mr. Coe.[472] And naturally that was the end of any hoped-for new basic look at the patent system. Thus advised they inevitably endorsed it as basically right, and recommended a few good corrections hereafter noted. They were considering some good topics when making their last report before supersession—tax benefits for invention, better inspiration and training for inventors, and study of suggestion systems and rewards.

[488] Countless hearings and bills in Congress, reported in other studies of this Senate series,[473] have sought the reform of the patent system, and so have three elaborate studies[474] under governmental authority with competence by conventional standards. These were first the U.S. Science Advisory Board's Committee on the Relation of the Patent System to the Stimulation of New Industries,[475] in 1935. Then the Temporary National Economic Committee, the well known and important Congress-sponsored Committee to consider especially monopoly and business cycle issues, presented in 1941 five very minor recommendations which have been accepted, others not, interesting data and hearings,[476] and Walton H. Hamilton's well-known monograph.[207] Then came the National Patent Planning Commission above noted.[472] Last was the Patent Survey Committee,[477] appointed by President Truman and Secretary Wallace in 1945 to replace the NPPC, with William H. Davis, a conservative patent attorney, as chairman [1] and three distinguished engineer inventors.[477] They could not agree, and never produced a report, though the present series publishes one of their studies.[478]

[489] Let us list our suggestions, and some most frequent proposals of others, approved or not, under the following five groupings according to their main general purpose, with cross-references to other suggestions serving the same purpose. We cannot attempt to make the cross-referencing complete, so wide are the ramifying influences of each law. In practice, serving any purpose likely entails hampering other purposes. E.g., every provision to improve the quality of patents probably involves more delay in their granting, and the consumption of funds that could have served other good ends. We conjoin some references and sometimes the initials SAB, NPPC, TNEC, or NAM, or otherwise indicate which commissions or authorities named above have supported the proposals.

a. Proposals for Improving the Quality of Patents

[490] Any achievement in this direction will probably reduce the numbers of applications and grants, and thus free some of the staff for further betterment or other work. Proposals in other sections below, which should likewise improve quality, are items 8, 16, and 18.

[491] (*1*) TAXATION AND/OR HIGHER FEES. Raising the Patent Office charges[479] from their present minimum of $60, averaging 31% of their cost to the Government,[668] would seem to justify more careful

treatment of a patent than the present average 24 hours of professionals' time (¶ 295), and would certainly eliminate from the applicants those who had least faith in the profit of patenting certain inventions, and those who had least money. This will at once arouse sympathy for the poor, garret inventor; but our statistical evaluation of his product (¶ 396–41) left us with no admiration for it. In any case a doubling or trebling of the fees would cause but a minute rise in the total costs of getting and defending a patent, and still less in the multitudinous costs of making and exploiting a successful invention.

[492] Particularly attractive is the plan of levying additional and progressively higher fees from time to time during the life of the patent, with the result that the great bulk of patents would be abandoned before expiry, when the inventor's hopes for them had appeared to be ill-founded, perhaps the patent found invalid, or when the invention had been worked but was now obsolete. In all cases the revelation and publicizing of the invention would have been accomplished, and the initial fees, covering say the first 5 years, would be kept low, to encourage abundant patenting; but the dead underbrush would be cleared from the path of progress. As Federico's statistics in Study 17 show,[146] this system is followed in every industrial country save Canada and our own, with the result that from 95% to 98% of patents have been abandoned before expiry in the leading countries, and only a third are kept alive as long as 10 years. The percentages kept are rising.[146] At the request of the subcommittee a draft bill was proposed,[480] and later at the request of the Patent Office a bill was introduced,[480.1] providing for higher fees, plus maintenance fees if the patent were to be kept in force to the end of its term. But an inventor or his heir who still held the patent, and who declared it had never yielded so much as the maintenance fees, could be excused from paying these for 13 years. We know of no reason why a patent with two so black marks against it (no assignment and no profit) should be automatically accorded favored treatment, unless it were a basic new start. Maintenance taxes have also been recommended by SAB, NPPC, Dr. Bush, the National Patent Council, and the Patent Office Society, and opposed by the American Patent Law Association.[480.1]

[493] (*2*) The UTILITY Requirement.[481] (¶ 209). Despite the law which says patentable inventions must be useful, the Office consents to mere operability. The British Science Guild [482] points out that in their country and all others save our own, granting patents to the first applicant encourages the hasty patenting of a new idea, perhaps a "scarecrow" or "nuisance" patent (¶ 288–91) rather than the time-consuming, careful development of the idea to a really useful state. This must be borne in mind when considering the abolition of Interferences (sec. (*17*) below). Senator Kefauver's original bill,[230] based on observed abuses, would have refused patents on drugs unless

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[480.1] The minimum fees would be raised to about $100, plus maintenance charges of $50, $100, and $150 if the patent were to be kept in force after the 5th, 9th, and 13th years, respectively, according to Senate bill 2225 proposed by Chairman McClellan and the Patent Office. The proposed fees, lowered by the subcommittee, unwisely, we think, would recoup only 74% of present Office costs. Senate Subcommittee on Patents, etc., *Hearing* of Sept. 4, 1962, on S. 2225, *Patent Office Fees*, 157 pp., pp. 3–5. With charts and international comparisons; and the subcommittee's Rept. N 558.

there were proof of serious improvement, and not the mere modification of a formula.

[494] (*3*) Opposition Proceedings. The commonest ground on which patents are invalidated by the courts is that the infringer has brought up new evidence that the invention had been made by someone else before the patent application. Hence many countries provide that a patent application, or a summary of it, shall be published before final issue, to invite objections from interested parties. Only citations of prior publication should be accepted, said SAB, to keep the proceedings cheap and *ex parte*, nor should the date of application be revealed. Further interference proceedings would still be possible, but reduced by this easier substitute. Such proposals were approved by NPPC and NAM,[474] were the subject of study by Federico,[484] and were embodied, together with Revocation proceedings, in a preliminary draft for the 1952 revision of the patent code. Then, on advice of the patent bar *et al.*, it was dropped with the other controversial proposals. But the subcommittee's report of 1960 endorses it.[485]

[495] (*4*) International Search Cooperation. We have proposed above (¶ 440), this utterly logical arrangement for doing once instead of many times, the colossal task of searching the world's patents, literature and practice to determine if an invention be new. Questions of whether or not to grant the patent, and on what terms, could still be easily decided by each country separately, according to its own laws and preferences. We have told how many European countries are proceeding to carry this through; why should not the U.S.? It threatens some jobs for patent attorneys and examiners, but the Patent Office has proved its preference for efficiency by working on reclassification of patents and mechanization of searching (sec. (*8*) below). It would seem logical to divide international patent searching between the chief industrial nations according to the fields in which each is preeminent, e.g., giving chemistry to a German office, various specialities to France, electricity to the U.S., papermaking to Canada, etc. A recent report by the Senate subcommittee [486] describes this and other kinds of international cooperation, and says, "The desirability of more actual administration of patents on the international level through international organizations becomes evident."

[496] (*5*) Nullity Proceedings From Government. These are similar to Opposition proceedings, but allowable up to a year after grant of a patent, and with the Government paying for the suit. The Patent Office would be empowered to cancel an improper patent, after hearing. A draft law for this purpose is in Federico's Study 4 for the subcommittee.[484] Stedman,[215] NPPC.

[497] (*6*) From the evils of Bogus patents, based on Collusion between litigants (¶ 285), or on various other deficiencies, no one remedy offers, but a number of those here proposed would help, here and there. Against collusion might help especially Opposition proceedings (*3*), Nullity proceedings (*5*), Compulsory licensing (*12*), and a Patent Administration (*18*). Patents of Addition, used in various countries with provision for settlement of interferences between the basic and the additive patents, and Petty Patents (*10*) might also help.

b. Proposals for Speeding the Issue of Patents

[498] The patent system is always praised for its work of disclosing and advertising inventions: less often mentioned are its grave shortcomings in the same respects, through patent delay, obscurity, incompleteness, and encouragement of general secrecy as compared with noncompetitive inventing (¶ 164–6, 272–280). Any shortening of patents' present secret stay in the Patent Office, from an average of 3½ years, would be a great benefit, as explained in ¶ 301–3 and in Study 23 of the present Senate series.[487] Of the many ways to accomplish this the easiest would be:

[499] (*7*) The 20-YEAR BILL,[488] limiting a patent's duration to 20 years from the date of application, unless it issue in less than 3 years, in which case it would run for 17, as now. The bill is aimed not so must against delay, which it still allows for 3 years, as against unconscionable delay, contrived by the applicant in order to postpone his monopoly 5 or 10 or even more than 20 years beyond the 17 intended. An additional and better measure against delay would be a shortening of the time required by the Office for responses, to whatever time seems needed in each case. Some responses might properly be demanded in 1 minute, after reaching by telephone or teletype the man who knows; others might be required in a day, week, or month. The 20-year bill has been approved by TNEC, NPPC, NAM, SAB, the Bone Committee, and half the patent bar.[489] Most countries figure the term from the date of application.

[500] (*8*) Various measures within the Patent Office could speed the patent process[308, 479] particularly MECHANIZATION and ELECTRIC SEARCHING, as mentioned in ¶ 166 and 204. This has been well begun by the Office with OSRD, MIT, and the Bureau of Standards. They start on Chemistry, because its vocabulary is an artificial international language, like Esperanto, and because being artificial it is logical, simple, and easy for people to learn who understand the things named. English too, to be used by machines efficiently, should be translated into a new dialect or "meta-language," Ruly English. The inventors have in mind ultimately to read this or even ordinary English by a reading machine (¶ 336). Bush.[490]

[501] Other needed measures for speed are to complete and even expand the RECLASSIFICATION OF PATENTS, spread it abroad through microfilm, (*21*) and get international cooperation in searching, as called for above (¶ 440). Europeans would hardly stand for such nonsense as taking 3 or 4 years to grant an average patent.

[502] (*9*) A REGISTRATION SYSTEM. Another solution for the problems of long delay and low validity in patents would be simply to acknowledge defeat and issue patents at once without examination for novelty, as do the Latin and the unindustrial countries; ¶ 299. But France is planning to adopt search, internationally, and probably that were a better idea. Zangwill proposes an interesting compromise.[491] A "patent certificate" would be quickly granted after but brief examination, for $25, printing with it the examiner's citation of references and opinion on validity, perhaps adverse. There would be no correspondence except on form, and the applicant could withdraw whole claims. This certificate would be little regarded by courts or anyone; but very few patents are ever sued on anyway. However,

any interested party could at any time for $200 call for a "thorough" search and issue of a normal patent, or a rejection, as found justified. Frost [492] finds a similar proposal interesting. The Netherlands is preparing to install such a system: those published applications which in 7 years no one has paid for examining and issuing or refusing, would be abandoned.[493] The Common Market is also considering the idea, with a 5-year unexamined limit. Since few patents ever attain importance, here is one good way of alleviating the patent law's fault of treating all inventions alike (¶ 245), although they differ so vastly.

[503] (*10*) PETTY PATENTS [243] (¶ 238) are another way for answering this need. They would be similar to the *Gebrauchmuster* of Germany, granted at once, without examination and cheaply, for short terms, on inventions recognized by their author as minor. Woodward [243] proposes and White [494] considers several kinds of patents, and Bush [495] at least two. SAB, Bone, Stedman.[496]

[504] (*11*) DEFENSIVE PATENTS SUBSTITUTE. Davis [497] says that perhaps as many as one-third of all patents are taken for defensive purposes, i.e., to have a more perfect legal base for blocking a patent attack by others, than could be won by merely publishing or publicly using their own invention (¶ 167, 8). For such a limited purpose it should not be necessary to use the full normal time of the Patent Office. Davis [497] suggests simply permitting that an application be abandoned and published right after filing, thus publishing the invention for $30, and obtaining the right to enter interference proceedings if appropriate should another claim the invention.[498]

[505] Various means of speeding issue in the Patent Office are discussed in Geniesse's Study 29,[308] and there have been proposals to reform interference procedure, especially by issuing one patent immediately, instead of waiting to settle the priority.

c. Proposals for Combating Abuses of Patents

[506] All proposals for our first purpose, Improving the Quality of Patents, would serve this purpose too, as would also sections (*6*). (*16*) and (*18*).

[507] (*12*) COMPULSORY LICENSE has been considered in the previous chapter, section 13, ¶ 463ff.

[508] (*13*) MONOPOLY. On this matter we would only call attention to the proposal of Langner (ft. N *180*, p. 54), that a defendant in a suit for infringement be permitted to plead monopoly tactics by the patentee, as justification for a free or compulsory license, and that the Department of Justice might intervene to help him. This would formalize present practice.

d. Proposals for Improving and Lightening Litigation

[509] All means for improving the quality of patents, as in our first group, should help in the present purpose, as should also sections (*11*), (*18*), (*19*), (*22*) and (*23*).

[510] (*14*) COURT EXPERTS. Judges are trained in law; patents likely to be sued on are 41% in chemistry and electricity,[499] and the rest

[498] A bill which passed the Senate would establish a file of general technical information, to be paid for by users, and would provide a convenient substitute for purely defensive patents, even if not fully as good. S. 868, passed Oct. 9, 1949, and Representative Crosser's H.R. 1711, of 1950, not passed.

in engineering, and moreover are usually on the newest, least familiar, most advanced frontiers of those sciences, like solid-state physics and high-polymer chemistry. So it should be obvious to anyone, who will think for a moment on his own incapacity in most of the newest scientific fields, that a lifetime spent on law does not qualify for understanding them all. And indeed this has been obvious to many of those considering patent reform, but not to the judges nor Congress, who have so far been content with the ancient principle that a judge is a man of learning, intelligence, and honor, and therefore competent to understand and settle all quarrels, if the opponents will but present their respective experts, who will explain to him the strange matters, from their opposing points of view. The unpleasant facts are shrugged off, that rival experts were hired who agreed to support the respective opposite claims, and that they are paid high fees to win by whatever means of didactics or bluff, and that their principal task is not to explain technology, but to convince the untaught judge that certain "inventive" ideas were or were not original, or did or did not require a flash of genius or luck beyond the powers of professional competence, at a certain date probably 10 or 20 years back, in a profession the judge knows nothing about.

[511] Three mild remedial measures have been suggested. One is for courts to refer back to the Patent Office for advisory opinions on the technical questions raised. (NPPC,[500] Stedman,[501] Bush [502]). They do now pretty well follow the Office's original decisions, on possible anticipations which the Office had the luck to find. A second suggestion is for experts, "assessors," to be appointed in some manner by the Government or court, instead of as partisans. Recommended by the subcommittee,[503] and by Bush,[501] NPPC and Stedman.[501] The last suggestion is to encourage arbitration of patent disputes.[504]

[512] (*15*) A SINGLE COURT OF PATENT APPEALS, instead of using all nine circuit courts and occasionally three others, would be another means for improving patent litigation, especially if the judges for this court were men of some slight scientific competence, beside having court experts as above. For another matter, it would prevent conflicting decisions and further appeal. TNEC, NPPC, NAM, Bush,[320] and the subcommittee.[503] It is appropriate to further centralize our institutions, as the means of transportation and communication improve. The opposition claims a single court would become too technical and rule-bound.[505]

[513] Regarding (*14*) and (*15*) Stedman observes:[501] "In other fields than patents we have met this type of situation [complication and abstruseness], once it became sufficiently acute, by setting up specialized tribunals—tax courts, labor boards, customs courts, workmen's compensation tribunals, FTC, ICC, and so on—tribunals which are subject to court control but which take care of a large proportion of the controversies."

[514] (*16*) GOVERNMENT INTERVENTION IN PATENT SUITS, where the public interest is concerned, to attack, e.g., either industrial monopoly or the validity or scope of patents, was proposed in Senate bills of 1942. The NAM opposed [506] them, saying that the Government can intervene now as *amicus curiae*.

[515] (*17*) ABOLITION OF INTERFERENCE procedure, especially if opposition be invited (*3*). Instead of our peculiar American institu-

tion (¶ 33), some would follow the European practice of simply awarding the patent to the first applicant. While this would tend to speed up the processes of inventing, as well as of patent application, it would encourage some of the worst types of patents, the "scarecrow" or "dragnet" types on half-baked inventions (¶ 288–91). R. E. Wilson says the American system of considering priority of conception "encourages a man to take adequate time to appraise his invention, work out details, and even discuss it with others, without jeopardizing his position as the first inventor provided he keeps adequate records." [507]

[516] (*18*) A PATENT ADMINISTRATION or Commission, to conduct patent appeals and trials, compulsory license and all other judicial or semijudicial business involving patents, has been proposed by Rice.[508] It would also have power to enter patent suits when the public welfare is concerned, or when one party is weak through poverty, or because an undercover deal has been made, as has often happened. Such a commission, as Stedman suggests (*15*) would become the more necessary, the more we elaborated the patent system with difficult economic judgments such as compulsory licensing, or different classes of patents, or the licensing of Government-owned patents, or making serious awards.[509]

[517] (*19*) BANNING SECONDARY INFRINGEMENT SUITS. An abuse sometimes reported is filing infringement suits against a few and threatening many users or retailers of an invention claimed to infringe a patent. It can be a potent weapon, without ever winning a patent suit. So Commissioner Ladd,[510] the TNEC, and Brown [469] have recommended that suits be filed only or first against the primary producer of the invention, unless the secondary parties can be proved coconspirators.

e. Miscellaneous Proposals

[517.5] (*20*) PUBLICATION OF APPLICATIONS. Unless Interference proceedings were abolished, or complaints restricted as in (*3*), the prompt publication of applications would bring a flood of challenges by people claiming earlier conception. But we might well publish the old or abandoned applications, the latter amounting to 38% of [511] all today, and more earlier. They could be a usable supplement to technological literature, even if their main ideas had been anticipated (¶ 483). American Bar Association.[512]

[518] (*21*) DOCUMENTATION. Still more informative are the 3 million American granted patents, published but not made nearly so accessible to inventive thinkers as they might be by completion of their reclassification (now in 309 classes and 57,809 subclasses), cross-referencing them, combining the unduplicated foreign patents and other references from technical and scientific literature, and distributing microfilm copies to libraries over the country and world, as proposed by the Commissioner and Newman.[513] We have spoken above ((*8*) and ¶ 164–6) of how patents' information could be made far more accessible to inventors by mechanized searching and an international library, and by lessening the delay and obscurity of patents. Bush.[502]

[519] (*22*) NAMING THE INVENTOR. Our law that the inventor or inventors must be named and must themselves apply for the patent and for any subsequent alteration of it, might be changed to follow

the custom of other countries which accept any person or corporation that is rightful owner of the invention. This would comport with the fact that today the corporations which order and pay for inventions are their authors in a truer sense than any one or two or three of their employees who work them out, and that it is an arbitrary and disputable decision as to just which men and how many should be named today, and a sometimes misused fact that the refusal of one of them to cooperate (for whatever reason) may block action.[512] SAB, NAM, American Bar Association in part.[512] Others disagree, seeking prestige for the inventor.

[520] (*23*) VARIABLE TERMS. We examined in ¶ 245 the strong but baseless tradition that all patents must be alike in all their privileges and requirements. If inventions were dimes there would be point in this; but they are infinitely variable, hence their needs and capacities vary. Other countries provide some flexibility by petty patents (*10*), taxation (*1*), limiting the term of improvement patents to their basic one; and defensive patents are proposed (*11*). We formerly allowed term extensions for some patents, but whether by rule or by private bills in Congress this proved unsatisfactory. Meier[457] and others have proposed longer terms for fundamental inventions, coupled with compulsory license. Hamilton and Stedman approve variable terms (ft. N *247*, p. 82). Our chapter 8 showed how the fundamental inventions, the greatest of all, receive little help from patents, which almost always run out before the profits start; perhaps longer terms, handled by a patent administrator, (*18*Q would help. Semipublic patent pools would do better (ch. 11). Proposals for a choice between a normal patent and a cheap and quick one unexamined for novelty, are taken up in ¶ 502.

[521] (*24*) COMMERCIAL PATENTS ON GOVERNMENTAL INVENTIONS. It is a debated question[514] whether we should follow the custom of the Defense Department and NSF in allowing the commercial laboratories which made military inventions to patent them for civilian uses, with a free license to the Government, or follow the custom of other departments in barring such patents, or should provide for compulsory licensing, or should have a flexible rule. The patents concerned are not very numerous, because while military invention brings great civil uses in the long run, it is not so important in the briefer life of patents. A PTCF study[515] indicated that 6% of patents came from Government contracts, and that 13% of these were worked commercially. Another study pointed to lower utilization, 7%.[515] The experience of a British governmental bureau to develop and exploit inventions is instructive, and not very encouraging.[516] The question has been often argued from a moral viewpoint, as to whether a corporation has a right to any ownership in an invention the public paid for. We would point out that the question is much more complex than that, as the subcommittee sees,[668] and that economists base their recommendations not on supposed rights but on public welfare. There will usually be open and hard questions of how much the commercial laboratory contributed to the invention through previous thought and equipment, and how much through further, later development for civil uses, how far the laboratory will consent to be paid with patent prospects, and whether the consumers' stake in the invention will be helped or hindered by a commercial patent in the hands of its developer. We and many have

said, under the first principle of patents (¶ 171), that a patent is often necessary to warrant a firm's carrying through an expensive development, for commercial uses. There is little use in paying an additional patent bonus for work already paid for and done. Our real main problem is the future, the work still to be done of developing and marketing the invention for its possible civilian uses. Will *this* work be better done under a commercial patent, as we usually think anent the patent system, or better done without protection? Sometimes also involved are our 5th reason for patents (control of quality, ¶ 172), or our 7th (needful concentration of production, ¶ 175–7).

[522] (*25*) OBJECTIVE TESTS FOR INVENTION. These have been asked for by many, including SAB. But we agree with Stedman,[517] Abramson,[517] and Edwards' special study of the problem for the Senate,[518] that objective tests cannot possibly cover such varied and unforeseen activities as invention, and that "The test of invention is not whether the contribution is useful—utility is [correction: should be] a *sine qua non* of patentability in any event—but whether it represents something which would not likely have become available to the public, at least for a long time, but for efforts inspired by the patent system and its rewards." We have argued elsewhere[191] and in ¶ 111, 160–3, that what must be somehow paid for may be a flash of genius, deep learning, hard work, or luck, the last occurring normally only as a byproduct of the first three.

[523] 17. SECRECY, has been considered above with 15, Know-how (¶ 482–4).

18. MONOPOLY and Big Business are great problems which we leave to more competent students, save for our remarks in ¶ 158,9.

CHAPTER 11

OUR TRADE ASSOCIATION PROPOSAL

[524] We have found (¶ 384) the trade association source of invention and research but a tiny quarter of 1 percent of all, but think it could and should be enormously expanded.

[525] What would be the traits of an ideal system for supporting invention and its pertinent sciences? First, it would provide that all who benefit from the work should join in paying for it, and that invention and its sciences, our greatest sources of progress should be more bountifully supported than ever before. To get the whole world to pay would be difficult, to be sure; our whole Nation can pay through governmental support; but it were desirable to invoke where possible the commercial motive and private management, in closest touch with the needs and thought of private industry. The inventing and also the science should also be in close relation with the universities, the scholars, and the great ideals of science: truth, human welfare, the pursuit of knowledge for its own sake, and universal publication. The optimal system should further provide that each discovery and invention be promptly practiced on the widest scale that is economic, without any wasting of time or money on quarrels over ownership and who gets the money, before the new idea shall be permitted to be used; nor should there be any monopolistic extortion, nor any delays through possible poverty or personal incapacity of the individuals who made the inventions. And every person who made useful contributions should be rewarded, the most fruitful sources be especially stimulated, and every actuarially promising field be attacked, however remote, uncertain or generalized its foreseeable benefits.

[526] To realize this ideal were quite an order. Different items of the desiderata are fulfilled by different ones of our 17 or so cataloged supports for invention. None gives all; but all could be served by our new plan for the trade associations. The patent system *attempts* to fulfill them all, but with the poor success we have seen, unable to do anything serious for most fields, and motivating only about a fifth of all (ch. 3 and 6–9).

[527] Though trade association inventing is today so tiny a fraction of what it might be, and though it has been sufficiently described elsewhere,[377 8] let us first recall its present status, from chapter 9, section 5. Some 384 associations in 1953–54 were conducting technological research or invention, spending $14 million, 45% of it in their laboratories, the rest elsewhere, 25% being for basic research.[519] Few patents are taken out, and these are opened to the members or the public, free or for small royalties.[520] The characteristic fields for the associations' activities that concern us are research rather than invention, coordination and encouragement of members' researchers, and problems affecting the whole industry rather than few members or a new

line, and service to firms too small to have their own research program.

[528] The smallness and other traits of the associations' present activity are to be explained by the following facts: 1. With their cooperative basis and volunteer leadership the associations are inherently unsuited to pursue, fight over and exploit *patents* in the commercial, exclusive, competitive, and profit-maximizing manner which is largely necessary to make patents pay for their large overall costs. We have observed the same indifference toward patenting in other noncommercial invention sources—governments (¶ 225), scientists, foundations (¶ 452). 2. The associations therefore restrict themselves chiefly to searches that neither patents, Government, nor other institutions will pay for. 3. Since most of their production is therefore free to all, they cannot charge heavy membership dues, since that would lead firms to withdraw and still garner most of the benefits of membership. From these three facts the associations stand perpetually condemned by the present arrangements to small dues, small creative programs, and small accomplishment in research and invention. They might do more [521] than today; they cannot do much. The same considerations apply to the professional and technical societies, and to agricultural and other cooperatives, which managed to put up an additional 6.9 millions [522] (¶ 388, 447).

[529] Evidently the crucial obstacle to the expansion of trade association R&D is financing it. This might be taken care of by Government grants, or, as would seem preferable, by affording the associations compulsory membership. The method of grants has been used in England, since 1919, and in Holland and Sweden.[378] Fifty British industries are now organized with R&D functions, covering 55% of manufacturing, and employing over 5,000 research people, of whom 1,450 are graduates or equivalent, and 950 administrative. Of their total income of £6.5 million in 1958–59 the Government contributed £1.7 million, through the Department of Scientific and Industrial Research, amounting to 0.52% of the governmental and 0.36% of the nation's total expenditures for R&D [523]. The benefits to the member companies have included not only the published discoveries and inventions, but sometimes confidential information, or patent licenses on free or reduced terms, personnel training, and the rights to influence the choice of researches, put questions to the staff, and engage its free time for their own problems, at cost.

[530] The British Government also heavily supports Research Councils, and the National Research Development Corporation, which holds 3,000 patents and applications (¶ 434, 439).

A New Plan for the Support of Invention [524]

[531] If inventive trade associations had *compulsory membership*, all their financial difficulties would disappear like dew, because they could impose dues as heavy as they please, for which the companies would reimburse themselves by the delightfully simple process of passing the charge on to the consumers.[525] At least most of it would

[525] A rather similar support is now accorded to the British textile and the French petroleum and steel industry associations, through taxes levied on production of those commodities. Green & Judkins, N 378, pp. 22, 23.

be so passed on; some might reduce profits, without affecting competition; one-half of this would be passed on to the Government in reduced corporate taxation. Invention and its researches would be more copiously supported than ever before; the limit of invention's funds would be set not by any familiar economic force, but by what the directors of the several associations (including their governmental mentors) thought was most appropriate, in view of the foreseen possibilities from the R&D, and the needs of the companies, the public and the Government. At the same time the latest inventions would be opened to all users.

[532] How give the associations universal membership? It might be done much as in the NRA of 1933–5, though this legal compulsion on firms to join was found unconstitutional in that case. A less objectionable, easy way, surely constitutional, would be simply to *grant patents on more favorable terms to licensed, semipublic, nonmonopolistic trade associations, than to noncooperating patentees.* And provide that patents later taken over by such an association, should receive like benefits. These more favorable patent terms might be a longer duration, such as 20 years versus 10 to a noncooperating patentee, and/or lower fees, freedom from the later taxation of patents practiced by most countries (¶ 492), and/or granting patents at once and without examination, to a licensed association. Of course such patents would be subject to later upset by a court, if sued on and found improper, just as in the Latin and smaller countries, and often here (¶ 299, 502). There is no requirement in the Constitution (¶ 31) nor in common sense that all patents or patentees be treated alike (¶ 245).

[533] The big and intended effect of all such preferential patent terms would be that, with the patents more desirable to a licensed association than to a nonmember, all the valuable patents would get into hands of the appropriate associations. These associations would tend to amass great numbers, through possessing, as stated, unlimited funds to pursue invention in their own laboratories, and to buy patents from other American grantees and especially from foreign sources. The *result*, from the associations' getting hold of all the good patents, would be not only a patent pool for the benefit of all, but also that these licensed, favored, nonmonopolistic trade organizations *would acquire in effect compulsory membership*, since no firm lacking all the good patents could compete with those free to use them all. At least no large and progressive manufacturing firm could; but on the outside might well remain thousands of little partnerships and small firms running a bakery, a hotel, a truck fleet, or the like, who would never make inventions anyway, nor use them except by buying patented equipment. They would continue as before, as might some small firms using past inventions. But the companies that matter for invention would all flock into the associations within a few years, quietly, painlessly, with no commercial revolution, and only a few lines of the patent and commercial laws having needed change. In a *few* industries, to be sure, this might fail to work sufficiently; so we might provide *in reserve* that a licensed association have eminent domain, to appraise and buy up any patents it required, as allowed today to the Government.

[534] Many patents are used in more than one industry, so free exchange of patents between licensed associations must be provided

for. Probably no interpool payments would be called for, since most inventions concern one industry primarily; and with unlimited funds available the atmosphere would not be commercial or grasping. Some permanent groupings of associations might also be desirable. Inventions and researches foreseen before making, as promising large benefits to more than one industry, or to one or more, and to the Government, would, with easy-going comity, be financed by these jointly, and carried out in whatever laboratories seemed most convenient. So, too, with all inventive and research efforts—the work could and would be carried out in any suitable laboratory, whether of an association, Government, foundation, university or private corporation; especially in the early years the great existing corporation laboratories would be relied on. And the tryout and further development in practice could be in one or two firms only, by arrangement, with their experience freely passed on, save where it were expedient, as per ¶ 174–7 and 540, to concentrate the working.

[535] What should the licensed trade associations be like? Much like those of today (¶ 527), and like those which the British Government supports on invention (¶ 529), and like our semipublic associations of the NRA, 1933–35, and in part like the patent pools which we found to motivate something like 5 or 6% of R&D (¶ 416 ff.), and like governmental and other nonprofit laboratories. They should proceed from our present associations, and act in general on their own initiative, but with the Government able to insist at any point that the public interest be served, that misbehavior, especially monopoly, be prevented, and personal malfeasance detected and punished. A Government member or several should sit on the board of directors, an auditor spot-scan the books and correspondence, and inspectors frequent strategic spots and consider complaints, which will not be few, from the rivalry of firms.

[536] In addition to R&D and a patent pool, the associations could assume these functions: (2) promotion of the actual adoption of improved methods, from their own, foreign, or other origins, including the sharing of all *trade secrets*. (3) Patenting their own inventions abroad. (4) Defense against American patents by outsiders, domestic or foreign, which are bogus, or unjustified by their trivial contribution. (5) Purchase, however, of all outsiders' patents considered valid and useful. A fair and generous attitude would be shown, to encourage outside contributions, especially foreign, for whatever they may be worth in general, especially in view of the past productions of a particular source; unlimited funds would foster generous appraisals, and assurance of no tricky dealing would encourage trustful and early submission of ideas, and cooperation in their further development. (6) Standardizations for the sake of public convenience, e.g., for joint use of products, higher resale value, and readier competition. (7) Collection and dissemination of statistical and other information. (8) Liaison between industry and Government. (9) Better organization within the industry, e.g., by arbitration of disputes, and better outside relations, e.g., with suppliers. Any controlling of price or quantity should be specifically prohibited, and constantly combated. Much can be learned from the mistakes and successes of the NRA.

[537] Another natural field would be needed *basic researches*, which could be assigned, perhaps obligatorily or with subsidy, to associations or groups of them, when more suitable or financeable than through governmental, foundation, or university support. Merrill points out [526] that in civil and mechanical engineering such basic work has not been so well attended to by American engineering schools as in Europe, nor sufficiently by corporations, all of which look mostly for early profitability. Another function today neglected would be invention for State and local governments, which as we told in ¶ 225 are the chief users of inventions in numerous fields, yet make almost none themselves. All these governments should form associations, or add to the functions of their present ones, to properly meet for the first time their needs for inventive progress. Where the work is peculiar and almost confined to Government, like sewage treatment, firefighting, or education, they might establish their own laboratories; but in other fields and these too, when the work is electronic, medical, or otherwise related to an established industry, they would doubtless call on the laboratories of other associations and existing corporations. The great point is that there be copious support for invention and research, and the second point is that the orders for invention should come from those having the most need, and the most understanding of their need.

[538] Still another function which could in many cases be assigned to various licensed associations, and which today begs grievously for support by someone, would be the creation of new fundamental inventions like the voice-operated writing machine, which today get little or no support, because neither the patent system nor any other institution is adapted to them. We have told their sad orphan story in chapter 8. The desalting of sea water languished for centuries in this limbo, but has lately been taken up by governments, our own to the tune of $12.5 million (estimated for 1964), with resultant rapid progress and utilization (¶ 353). Our National Science Foundation, and various universities and private foundations (secs. 3 and 7 of chs. 9 and 10) do something, especially in fundamental researches, and with higher appropriations might well do more, or other Government offices be used, for this and certain new starts not related to any present industry, such as the reading machine (¶ 336), microprinting (¶ 337), novel indexing and various police techniques (¶ 347), inventions for the physically handicapped (¶ 350), atomic inventions and new power sources (¶ 353), hydroponics (¶ 358), and quartz (¶ 361). More suitable to the licensed associations might be calling on the radio and electronic industries to produce radio systems and the audiovisor for home-printed newspapers, point-to-point television, etc. (¶ 338–41), and the great electric machine for generating supreme music (¶ 342–5). The automobile industry, though it has failed to come up with a secure car lock, might be paid or directed to produce one (¶ 352), as well as the automatically guided motor car (¶ 351). The cheap prefabricated house (¶ 219, 367) would belong with the building industry.

[539] In all these cases, where a much needed invention is closely related to an industry which has nonetheless failed to produce it, some new stimulus is evidently necessary, either a Government command, or a subsidy, or the unlimited funds of the proposed associations.

[540] One further problem of the associations needs consideration. As a rule, each of their patents would be open to use by all members of any association. But sometimes this would lead to unnecessary duplication of facilities which could not be fully utilized. This situation is met by patentees today through granting only a restricted number of licenses (unless condemned by a court to compulsory licensing of all applicants). Our associations should sometimes follow the commercial practice of restriction, particularly in inventions that will require further refinement by the manufacturer, as commercial use will reveal the needs and clues, and in such *parts* of inventions as will call for building costly dies and great, automated machines for most efficient production. Copyrights are a parallel case, since a book's prime costs, extending from the ideas to the printing plates, are almost everything; hence book copyrights are rarely licensed at all, and may last for 56 years. But if single parts need maximum scale production this need not concentrate a whole product or industry. If say a difficultly compounded ingredient, or a control device for a large machine needs noncompetitive, maximum-scale manufacture, it could be made by only one or a few firms, and shipped by them to competing assemblers, as often today. To which firms to allot the limited licenses might be a sticky question, but there are familiar ways to solve it, with Government supervision, e.g., competitive bidding for the lowest supply price, as on Government contracts. The problem is met and handled today in the British textile industry, through two associations, one of which owns their patents, and licenses some to single firms.[527]

THE MERITS OF THE PLAN may be listed as follows:

[541] 1. UNLIMITED FUNDS become available to support invention and all its pertinent or basic scientific researches (¶ 533), the costs being for the most part simply passed on to the consumers, whereas today a firm's raising its prices is fraught with competitive difficulties. It will be the first time in history that any important institution possessed unlimited funds. With such wherewithal and the plan's basis in both Government and industry, it proffers funds and favor for auspicious *projects that no other institution provides for*, including the great majority which the patent system cannot assist (ch. 6), and the projects of commercial field but quite uncommercial delayed or too risky benefit, which government, universities, foundations or professional associations will not touch because the inventions smell of commercialism, but in which private industry cannot smell profits early and sure enough. The fundamental invention (ch. 8) is the most noteworthy of these gardens untilled. *Custom-barred inventions*, balked by a standardization (¶ 215–7), would get a much better chance, since an industry, organized in its association, could claim authority to change the standardization, just as the FCC has power in radio, and the ICC in railroading. *Inventions not assessable upon their beneficiaries* (¶ 222–3) would have a better chance, perhaps through a Government order to the appropriate association. Unlimited funds also vouchsafe, for all kinds of invention and research, *continuity* of effort, facilities and personnel over long periods of years, something often lacking in the ups and downs of a firm's prosperity and directions of interest, or in congressional appropriations. The evils of excessive and insufficient rewards (¶ 259–60) would be reduced.

[542] 2. PATENT POOLING would be accomplished, practically completely, all the best inventions from any country being opened to all who wish to use them. Exceptions made where the public interest calls for large-scale working have been mentioned in ¶ 540.

[543] 3. NO DISCOURAGEMENT OF NOVELTY would be imposed upon invention, whereas the patent system, and secrecy temporary or lasting, and commercial cost accounting, all decree that the whole cost of making inventions and their preliminary discoveries, and of all a firm's unsuccessful efforts to the same ends, must be assessed upon the purchasers of the respective successful inventions, if possible. Thus the new way is taxed, while the old way goes free, as we made clear in ¶ 253–7. Neither would there be any obstruction to the adoption of the better new way through refusal of a patent license, for reasons of monopoly or any other motive that might profit a patentee but not a nation. The evils of "bogus," "scarecrow," "dragnet," "fencing," and "delayed" patents (¶ 285–91 and 301–3) would be mostly swept aside. The time an invention needs to spread to all major firms in an industry, which in Mansfield's cases averages 17 years,[528] would be shortened. We ask furthermore that the semipublic associations pursue special programs of combating secrecy (¶ 272–80, 425–7), hauling out trade secrets, and getting the member firms to know and actually use the latest and best knowledge and inventions, from whatever source derivable. All improper *suppressions* of inventions, which we found (¶304–19) to be important in the aggregate though not in the way commonly charged, would be prevented, almost wholly. But inferior inventions would be kept out of use (¶ 169), and quality could be controlled (¶ 172).

[544] 4. AN END TO DUPLICATION of inventive efforts, which we found in ¶ 179–82 to be usually wasteful when it leads to different solutions to circumvent a patent; certainly it is wasteful when it evokes identical solutions. Also reduced would be wasted efforts to invent along lines which the most competent authority to be found in the industry would condemn as proffering too little chance of success to be worth spending the people's money on.

[545] 5. MANAGEMENT BY INDUSTRY, rather than by Government, foundations, or any institution, would be an advantage for the commercial, usually manufacturing fields which would be committed to the trade associations. These associations are in closest touch with what is wanted and feasible, and know how things are easiest done in manufacturing, communication, transportation, etc. We do not say that the officers of industry are better or wiser in general than those of Government or universities, but that they are more informed on these problems they would take up.

[546] 6. THE SMALL FIRMS, which today do little for invention and less for research, would join in their support, and be encouraged to submit their problems to the helpful association, and to keep up with the latest inventions they might use. We have great industries today, like mining, quarrying, fishing, lumbering, construction, toys, furniture, foods, and all the service industries like hotels, restaurants, and stores, in which no firms are great enough to be incited to strong research programs, and in which comparatively little progress is made. A glance at a table of R&D expenditures, such as one comparing these financed by industry, against net sales,[529] shows a ratio falling from

4 to 3% in instruments, chemicals, electric equipment, and communication, to 0.4% in lumber, wood products, and furniture, or in textiles and apparel, and to 0.3% in food and kindred products. The preeminent example of small business is agriculture; but it has been rescued by governmental realization of this need, as well as by large companies taking over the making and inventing of agricultural implements.

[547] 7. THE COSTS OF THE PATENT SYSTEM, which we found in ¶ 261–9 to add up to something like a hundred million dollars a year in direct costs, would be mostly saved, when patents were little fought over, and most of them perhaps granted without examination, on demand of a semipublic trade association. *Speedy publication* (¶ 164–6) would also be assured for such.

[548] 8. TREND. Social forces and the tide of times are apt to be stronger in the long run than all our politics and personal preferences. So it is well to be on the side of the future, or at least to realize how the trend is setting. Trade associations, which hardly existed before 1910, patent pooling, and comity between big businesses if not monopoly, governmental regulating, and cooperation between industry and Government, have all been increasing in modern times. So is it not to be expected that some sort of patent pooling, and some sort of industrial organization with Government participation or supervision, is likely to come about? And that the main question is not what is the trend, but whether we should further it or obstruct it?

OBJECTIONS TO OUR PLAN

[549] 1. THAT THE PLAN WOULD USE THE PATENT SYSTEM TO DESTROY IT. *Answer:* First, in abstract logic, would there be any impropriety in using A to destroy A, in order to substitute a better B?

[550] Second, in fact the patent system would not be destroyed, but much reduced and modified. Patents would still be granted, under the same rules as before and universally in the world, save for certain changes above proposed. And they would still be valuable, both to the associations, to maintain their obligatory membership and powers of controlling quality, standardizations, and sometimes sufficiently large-scale manufacture, and also of value to all inventors outside the association laboratories, to wit some American firms, the free-lance and occasional inventors, and the foreign firms, who would all find in their patents a way for demanding a sufficient reward, just as of old. But the costs of the patent system should be much reduced especially from less lawsuits (¶ 547). Filing patents abroad would continue as before.

[551] 2. THAT THE PLAN PROPOSES MONOPOLY, WHEREAS IT IS COMPETITION WHICH HAS BUILT INVENTION AND AMERICAN INDUSTRY. *Answer:* In strict language, the plan proposes no monopoly, but a great attack against it. Monopoly means a union of sellers. The proposal is for monopsony, union of buyers, of invention. This could *conceivably* be oppressive, exploiting the inventors, but we see no reason whatever to expect this. For the monopsonies would possess unlimited funds to offer for patents, unpatented inventions, and services of inventors and scientists, and their main motive for existence would be to encourage all these; so why should they underpay, defraud, or anywise deter

them? In any case the main inventive activity in this country would be in the laboratories financed by the associations. Here the conditions of organization, pay and incentives would be quite the same as in the laboratories today of corporations, the Government, foundations, associations, etc. So why expect less efficiency? But there could be a greater result, through more funds and better planning and purposes. Each scientist, technician, or manager would still, as today, be competing with his peers, in the same laboratory, and in those of other associations that could use his skills. Or he could, if dissatisfied, switch to Government work, education, individual corporations, etc.

[552] So much for the proposed monopsony (of buyers). Now as to sellers' monopolies. Let us first recall that the patent system aims at such monopolies. Schumpeter is often and well quoted, that invention cannot take place without some degree of monopoly, some assurance of a "rent," a higher price on the novel product, that will not be immediately snatched away by competition. (Cf. ¶ 217.) To be sure, very large production may substitute for monopoly. A second exception, or modification, of this law is proposed by our plan, viz., that monopoly by firms (through patents etc., today) be usually swept away. But there would remain the monopoly of the organized industry with its control of unlimited funds, subject always to governmental oversight. Such monopoly *by industries* is inevitable in any case, and is largely though not fully complete. E.g., the automotive industry has an inevitable monopoly on land transport for 1–100 miles, weakened only in part by the competition of rival forms of transport (railways, walking, water and air transport, etc.), and by the competition of housing, sports, and everything else for the consumer's dollar. This incomplete, industrial monopoly inevitably continues under whatever plans, but monopoly *by firms*, the source of all fears and protests, would be reduced, so far as it has been based on patents, secret processes, and their prolongations in time through trademarks, good will, and the momentum of a head start.

[553] To be sure, the inclination to monopoly is as universal as original sin, so the forming of more and stronger trade associations would give many incitements to exceed their lawful purposes and contrive sellers' monopolies of this and that, by fixing prices or limiting markets, quality, or service. (If they agreed to limit advertising, which the late Senator Kefauver found a curse in the drug industry,[230] so much the better economics.) Or they might itch to contrive monopsonies toward labor or supplier industries. Such exploitive tendencies should certainly be combated constantly by the Government agents within each association, and by all the appropriate laws that can be devised, and by the trade organizations of the suppliers, and by organized labor, and by a consumers' bureau in the Government, such as has been often demanded to watch over the public's interest, against other abuses beside monopoly. Our proposed plan would not so greatly increase the chances for monopoly, over the countless opportunities that already exist. With the new defenses proposed, this danger should not be rated high. We must especially remember that monopoly would be strongly and *certainly* combated by the proposed pooling of patents, know-how and secret processes. The freedom of every firm, including the newest comer, to use all the best and latest

products and processes should certainly *intensify competition*, and encourage many to use the same best plans, fostering standardization and further sharpening the competition. And if there be any monopolistic sins in present-day trade associations, and patent pools—such charges are often brought against the patent pools and cross-licensing agreements—here is a new and potent way to combat them. All in all, our plan tends against monopoly.

[554] The argument that competition between firms, armored by patents, has worked well in the past, carries little weight in logic against an argument that something else would work better, specifically trade association inventing. Similarly, Jewkes' argument that the major inventions of the last 60 years started largely with individual inventors, fails completely to prove that the modern laboratory system is not better (¶ 396). Indeed, the whole drive of invention has always sprung from a genii within us which whispers: Though A has been good hitherto, B would be better.

[555] Every plea for adoption of something new should be checked so far as possible, by examination of the cases where it, or something of the sort, has been tried in the past. And so we turn for partial analogy, to those industries which have had less inventive competition between firms, due to Government support, patent pooling, comity or need of large scale. (There always remain at least interindustrial (¶ 552) and international competition, as we said.) Has the intergovernmental art of war been unprogressive, or has noncompetitive science? The principal commercial industries characterized by patent domination, pooling, or comity, always more or less inclined toward sales monopoly too, have included the automobile, aircraft, oil refining, bottles, and all the industries producing electric equipment or communication, including talkies and orthophonic phonographs. The completest monopoly, the telephone company, has the greatest invention laboratory, and a good record of progressiveness.[550] Only the first two industries, autos and aircraft, have been accused of unprogressiveness, so far as the writer is aware. Of these, the aircraft charge would seem false, since America has always been a chief exporter of aircraft, and autos, too. The automobile, world over, has been peculiarly unprogressive in its chief basic, gasoline-engine type for the last 50 years, though making good progress in refinements and quality. Its sound early variations, such as steam, electric, and air-cooled engines, have almost dropped out. We may contrast the standardized stagnation of autos with the variety and progressiveness of the trucks and automotive equipment produced by the same companies, and thereby see that it is the public which is responsible. An auto is a uniquely large, costly, complex, and dangerous collection of machinery, such as is elsewhere sold only to engineers, and yet it must be sold to Tom, Dick, and Harriet Public. And it must be serviced by roadside mechanics, wherever it may get into trouble. Probably hence, and not from any conservatism due to patent pooling, comes the cautious policy of the auto manufacturers, avoiding all revolutionary changes and not seeking to get far ahead of each other. For the more important changes they do accept, such as the four-wheel brake and finger gear shift, they follow tryouts first on a small scale in Europe, and when

[550] With the single probable exception of wire recording. ¶ 317.

proved acceptable there, adopt them throughout the American industry simultaneously.

[556] Contrariwise the least inventive industries have usually been those with the most competition, like clothing, foods, furniture, lumbering, construction, as we said (¶ 546). In short, the test of experience refutes rather than supports the idea that inventive progress depends on interfirm rivalry anent invention. Furthermore, in our historic parallels the monopoly was almost always incomplete, and therefore the funds for invention were limited. Were that weakness eliminated, the inventive program would certainly have been greater.

[557] Again to summarize the monopoly question, competition between individuals, industries, and countries is inevitable, or unaffected. Only competition between firms is concerned, and that would be reduced in field but sharpened. Farms, ships, and most means of production are old inventions open to all, yet that does not eliminate but heightens competition amongst them.

[558] 3. THAT THE PROPOSAL IS UNCONSTITUTIONAL, because the Constitution (¶ 31) authorizes only patents to inventors. *Answer:* If this interpretation were accepted, then no sale or assignment of a patent could preserve its validity, and our present system would fall. Under our proposal patents could be granted to inventors as before, but subject to assignment as before.

[559] 4. THAT OFFERING UNLIMITED FUNDS IS UNHEARD OF AND UNECONOMIC. This is a serious charge, that the power of the associations to support unlimited research and buying of patents, by simply raising their dues and passing on the cost to the consumers, is a new kind of institution, has no economic laws to guide it, and might lead to excessive spending on research, for the profit, glory, or creative satisfaction of the men running it.

Answers:

[560] (*a*) The Government is to be always represented in the associations with power to control abuses; and the profuse trade and scientific press, and rival companies and associations, are there to report facts and bring pressures. Care might be taken that the directors of the association, while drawn from companies, probably the larger ones, should be protected against further continuing domination by the same.

[561] (*b*) The rivalry *between industries* (¶ 552), and with foreign countries in industries having international trade, would deter industries from burdening themselves with excessive charges of R&D.

[562] (*c*) While the pacesetting for invention would be thus only partly controlled by known economic laws, a situation, as little understood or still less, is familiar, working, and accepted, in about 30% of our economy, viz., its 30% support by Government and by philanthropy. Their budgets are so regular from year to year that they are evidently controlled by socioeconomic laws, though our social sciences may not yet be advanced enough to explain these. Our classical economics is based on markets, where numerous buyers and sellers freely compete, a different situation from Government or philanthropy. Since these nonetheless work regularly and acceptably, why not trust Government a little more, to exercise sense, and trust our new institution in between Government, philanthropy, and business?

[563] (*d*) Our proposed institution would grow up only gradually. If abuses appear they could be corrected by the always superior authority of the Government, and the scheme modified or retreats ordered if they seem called for.

[563.5] 5. THAT TRADE ASSOCIATION INVENTING HAS BEEN TRIED in America and England, and found to produce hardly any inventions of importance. *Answer:* The employment of trade associations on R&D has hitherto always been so very limited in funds, as we made clear in ¶ 528, that merely minor results have been inevitable, and directed toward such researches (rather than invention) as cannot be secured through the patent system, nor through commercial motive of a single firm. Our proposal would totally change all this. To say that the associations' present small performance forebodes the like for their future is like saying that since the child Johnnie Smith has built no houses, he will be unproductive when grown a man.

CONSPECTUS

[564] What would be the picture of inventive America after this plan had become established? First, all the old kinds of inventing, patenting at home and abroad, and dealing with patents would continue as before, but in altered frequencies, some much reduced. There would still be amateur, even crackpot inventors and patentees, and they would continue to do little save waste their time. There would continue to be a great many specialized freelance inventors, and engineers, chemists, executives, and small companies operating independently of the associations, and often doing good work and taking patents, especially in the less organized, gadget, or improved fields. But their one good market for their inventions, unless adapted only to their own business, would be a trade association, with perhaps a choice between such. They would be well received there, and rewarded for anything new and good, especially if patented; but they might well receive small rewards for any contribution, however incomplete, such as pointing out an unrecognized source of trouble, or sketching a hard invention they had not the resources to carry through. The unlimited funds, and public-spirited purpose, of the associations should make them generous toward all useful kinds of helpers. The outsider's reserve power, through a patent, to compel just payment, would rarely be invoked nor needed, unless in the case of foreigners' patented inventions. When these came from the great foreign trusts, like Imperial Chemical Industries and I. G. Farben, they would sometimes be of great value, and backed by American patents and the financial power to manufacture in or export to this country; so the foreign company would be insistent on a maximum recompense. But they could be paid off, as often today, by cross-licenses on American inventions patented abroad, a sort of extension of our trade association plan to the whole manufacturing Free World, or to an Atlantic Union group. The strong movements toward European or Atlantic freer trading and federated organization make such arrangements likely and important aspects of our future.

[565] Finally, there would remain the larger companies with their laboratories or at least a technical staff, which would continue to do some R&D, for themselves or their association, especially at the start, and perhaps keeping even half of it. Retaining minor benefits of a

head start, and closest adaptation to their own business, they would usually turn over their patents and know-how to their association, for a good recompense, and often would do research jobs for it, on which they had some special suitability.

[566] At home, then, a practically complete freedom for any firm to use any method known, without a penny's penalty of royalty nor saying by your leave; and freedom for any inventor to try to improve almost any invention, and to hope for some reward if he accomplished or learned anything useful, even if he could not carry an invention through to patent or production, nor even get beyond some good discoveries. But most of the R&D would be carried out in great laboratories of the associations, government, universities, or foundations, with unlimited funds at the disposal of the associations. And for the first time in the world's history we should have some means better than philanthropy, to support needed *fundamental* civil inventions, whose expensive plodding goes sadly slow while there is no way to pay the bills.

[567] Since civil invention and research are for all, and therefore should logically be paid for by all and used by all, is not the proposed plan the most logical one, which would still leave invention in the hands (mainly) of private industry, instead of handing it over to Government, to which 65.6% [531] of all R&D, without counting tax exemption, have already been entrusted?

Approvals of the Plan or of Related Ideas

[567.5] The Commerce Department has requested, and received, some congressional approval, for a "civilian industrial technology program," to develop civil technology by research, and by stimulation toward adopting better methods known. Especially aimed at would be the least inventive industries, like textiles, and building, which are generally those of smallest scale and strongest competition. (Cf. ¶ 436 and ¶ 546.) Agriculture, mining, fisheries, typically such, have long been helped by Government. If the improvement of agriculture were left to family scale farmers, its progress would be near zero. Funds are proposed to be supplied to universities, engineering schools, and existing research institutes. The Department's bulletin adds, "It is hoped that industry will initiate broad industrial research associations with which the Department might contract to augment industrial support." [667] A good start on our plan. There should be a small professional staff in the Department for administration. "Determination of eligibility for contract awards and direction of the research program will be made with the advice of advisory boards composed of industrial and labor leaders, educators, and professional men well versed in both science and the technological needs of industry. The National Academy of Sciences will be asked to appoint the advisory board members for each industry." [667] Related institutions abroad are mentioned in ¶ 529.

[568] Stedman: "Patent pools probably are an essential instrument in today's economy. But in view of the power that they yield, the choice seems fairly clear: either they must do a thorough job of self-policing or the Government must take on the job of regulating them

and their policies to assure that the paramount public interest is promoted, not thwarted." [532]

[569] Melman ends his Study 11 with the conclusion: "Henceforth . . . 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." [65]

[570] Kottke would keep the electric industries in private enterprise, but with protection of the public interest. "First, there should be at least one large centralized laboratory in the communication field and at least one other in the heavy current field, sufficiently well endowed to undertake investigations of no immediate utility and to continue the work substantially unimpaired during business depressions. Second, there should be at least one leading concern in each major field with interests vested in as many lines of activity as practical for a single enterprise. Third, there should be a considerable number of strong concerns, each of which confines itself to manufacture of apparatus of one type, or to the provision of one kind of service, and there should be an opportunity for other such companies to develop. They should have prompt access to the findings of the centralized laboratory and, if there is a patent law, the right to employ its patented techniques for all purposes related to their field. If the central laboratory is part of the organization of a leading concern, these other companies should share on an equitable basis the cost of maintaining its program. Fourth, independent investigators should have ample opportunity to carry on studies which envision fundamental departures from present techniques." [533]

[571] Rivise, a patent attorney, called for outsiders to overhaul the patent system, and for more patent pooling, arbitration and discouragement of litigation by trade associations. (See ftN *470*, p. 154.)

[572] McBride: "Most of those appearing (at the Sirovich hearings) would welcome a clarification of the rights of industry to pool patents or grant reciprocal licenses. . . . Provided some practical means were offered for aiding industry in exchange of patent privileges without danger of breaking down the proper competition. [534]

[573] Hillier, recounting how scientific resources uncovered since the war have been prevented from coming into medical use by the costs of development, suggests as remedies Federal funds, or a foundation, or "a pool of private companies subsidized by national or local governments." [535]

Chapter 12

THE NATURE OF INVENTION AND OF INVENTORS

[574] Invention is much the same thing as scientific discovery, novel artistic creation, and innovation in business and social affairs, but in its own technic field. The students commonly call these all "creativity." One may truly say that to understand the nature of creativity and how to promote it is the most important problem in the world. For this could unlock the doors to the solution of all other problems; it could be the key to the key-rack; it could be the "open sesame" to progress in every aspect and direction, the cure for all ills and the means of attaining all goals.

[575] Many have essayed this supreme problem, especially in the last decade, in which governmental assistance has become important through the National Science Foundation, the Office of Naval Research, the Air Force, and the Office of Education.[536] Our Notes for this chapter, Nos. 536 to 600, may be considered a selective Bibliography on the Psychology of Invention and Discovery, including the list in N 600 of works we have not cited in any particular place, but have consulted and thought useful, as well as some works cited in earlier chapters. For inclusion we have favored especially the more recent works, in English, and relating more to invention proper. It is not our intention nor capacity to present a thorough discussion of the psychology of inventing and discovering, but only to develop a few of its principles which the other writers have commonly approved, but in somewhat different terms. We shall speak especially of the ambivalence of knowledge, and the quest for the habit-free mind.

[576] For a beginning, much as we distrust definition in social science or psychology,[104] we must again attempt at least a partial definition of invention (¶ 111). If it were simply the solving of a physical problem in a way new to one, then every one of us, along with the smarter sort of chimpanzees,[537] can be an inventor. No, invention is much harder than that—it is finding a new way that is *good*, and that has never been found before and developed and put through, anywhere in the world, at any time. Just as almost anyone, by working at it enough, could become an athlete, but to become an Olympic champion would be quite beyond our capacity, so any student of geometry, engineering, or chemistry learns to solve problems therein, but to become a true patentive inventor he must outrun the whole world. Even the Olympic champion need outdo only those lined up to start; but the inventor must beat all former records too, and accomplish what no one before him could who ever tried. Possibly no one before him has ever tackled that particular problem; but even then he would be refused a patent unless his solution was so ingenious that no one else *could* have found it, unless by talent or luck. Invention and

discovery, in their honored, highest type are *very* hard. Few are capable of them,[538] and still fewer succeed.

[577] To be sure, invention extends downward to a lower kind, which is simply the *logical* working out, from known elements and principles, for the best solution of a newly posed problem. A vast amount, probably the majority by cost, of all the $14 billion for 1961 R&D, goes for this easier type of invention or discovery. A solution so arrived at is rarely patentable. This kind of invention is not our main theme, because it poses no problems for Economics nor Patent Law, except the problem of diminishing returns from shortage of suitable talent (¶ 98–100). It is simply an industry whose problems need concern only its participants. We outsiders may simply rest assured that the more raw materials of money and well trained men are poured into that industry, the greater will be the output, of this lower kind of invention. Our present concern is all with the higher, much harder type, in which the inventor must outrun the world, not in a race where he is the only entrant to date, but where many may have tried on the same problem, perhaps for centuries, but no one has been able to put the pieces together.

[578] *Why* have they all failed, when a way really existed (though perhaps only recently) to put the pieces together, as was proved by the final success? Here is the nub of our problem of how to invent and discover. It lies *not* in that routine, logical industry, but in how to solve the *baffling* puzzles. If they were not baffling they would already have been solved as soon as wanted, by that logical method.

[579] A principal answer lies in the fact that *knowledge*, i.e., being well informed on the problem attacked, with all the scientific principles and parts that seem needed, with skill in dealing with such matters, and maybe practical experience too—all such *knowledge is ambivalent*, both good and bad, the inventor's indispensable help, and likewise his undoing.[539] The *benefits* of knowledge, to lead to the best solution among all conceivable, without wasting time on ideas impossible or that have been tried before and found not to work—these benefits are so obvious that they need no further word. The harm, the ruin in full knowledge of the prior art, is that it tends powerfully to lead the inventor's mind along familiar channels, in endless reconnections of his own previous mental hookups, which are usually also those which other men have thought of, and perhaps tried out and found wanting. They include all of one's personal thought-habits, the customs of one's world, and supposed "laws" of science, which may well be misunderstood, or even possibly false. Constructive thought consists of making appropriate connections between different memories stored in the mind. The farther apart, as it were, these memories are, and the less habitual, or totally untrodden, be the path between them, or say the less they seem to have to do with each other, the harder it is to make the (really appropriate) connection between them. The inventor needs, in short, freedom of *association*, a habit-free mind—and yet to combine this *somehow* with a mind stored with all possibly pertinent information.[540]

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[539] As the neon inventor Georges Claude said of these facts "qui vous renseignent . . . en vous cassant les ailes—which inform you, while breaking your wings." Qq. idées sur l'inv. et la recherche sci.; *Chimie et Indus.* 9: p. 1017 of 1009–22, May 1923.

[580] Puzzles and conundrums are deliberately constructed to use our thought-habits in this way to defeat our effort to solve a problem. For instance, try to explain this one: Two Indians walk silently through the forest, in single file, a big Indian and a little Indian. The little Indian is the son of the big Indian, but the big Indian is *not* the father of the little Indian. Or solve this one, if you have not heard it: What has four wheels and flies?

Some Immediate Remedies for Solving the Puzzles of Invention

[581] Claude,[539] like Kettering [541] and some others facing the horns of this dilemma, of the ambivalence of knowledge, preferred to saw off one useful horn, knowledge, deliberately refusing to look up the literature, until he had thought up a solution that justified hope. "Cassecou, cette méthode? Peut-être; pas plus pourtant que l'autre, la sage, n'est *stérilisatrice*." [542]

[582] Kipling gave thanks for having "two separate sides to my head." Our basic problem is to get the two sides to working together, the side packed with information and old habits, and the side full of ignorance and hence free-ranging possibilities of originality. Claude and Kettering would use first only the ignorant side. Most people try the opposite side and fail. Another solution occasionally resorted to is to employ separate men.[543] E.g., a corporation will set a graduate student in a university to working on their problems. With his ignorance he is likely only to repeat their efforts and find nothing both new and good. But on the other hand, with his less trammeled mind he *might* perceive something they had steadfastly overlooked.[544] (And in any case he gets training, and a good introduction to the company and its work.) A much commoner form of this plural-men procedure, and one that we have said, should be more seriously handled (¶ 400, 458), is to invite suggestions from wide circles, and then have these criticized by authentic experts who should somehow preserve a hopeful, searching outlook for the very few ideas which would be found worthy of development by further experts. A method constantly employed by the laboratories is to consign the building, testing, and other more routine work on inventions and research to varied technicians, since such work uses up, annoys, and deadens the rare originative minds, and the routine specialist can be more expert at it, or youthful engineers be trained through it. Simple multiplication of the seekers helps speed success through more chances albeit with falling efficiency. Scanning the ideas of many prior contestants, and of one's own earlier work, has its good as well as stultifying possibilities.

[583] Another means for obtaining an equipped yet habit-free mind might be to add the help of a robot, an electronic computer. For they can develop habits, or not, as ordered, and can do anything they are instructed in, overlooking nothing. In particular, they have already been taught to translate between various languages.[545] Translating, with or without a machine, from English into Ruly English, the new dialect the Patent Office is working on for mechanization pur-

[542] "A method for breaking your neck? Perhaps, but no worse than the other, the wise way, which *sterilizes*." Our ftN 539, p. 180.

poses (¶ 500) might yield a more suggestive text, expressing more accurately the real meanings of a problem and its proposed solution. Suppose we dictated the second of the above conundrums (¶ 580) into a robot instructed to translate it into German and the particularly regular Esperanto, including all possible alternative meanings. The machine would type out: *Was hat 4 Räder und* (*fliegt*) (*Fliegen*) ? and in Esperanto *Kio havas 4 radojn kaj* (*flugas*) (*mušojn*) ? And there you perceive the answer to the conundrum. Similarly the robot chess player can beat any ordinary player, because it thinks of so many possibilities. Or suppose we called for the first conundrum to be translated into French—its last clause would come out: *mais* (*le grand Indien*) (*la grande Indienne*) *n'est pas le père du petit Indien.* Again you perceive the solution, which your habit-trammeled mind had missed. Only a nonhuman device can think of every possibility, immune to every habitual association, and make unprecedented connections, as well as the old and habitual linkages which have been thought of and found inapt.[538] Arnold cites cases where such mechanization has helped invention.[546]

[584] A newly devised way to get cooperation between the two "separate sides to my head" is "brainstorming," devised and taught especially by Osborn.[547] The two sides are to work not simultaneously, lest imagination be repressed by criticism; but first the ignorant, free-wheeling fancy is to have its fling; only at later sessions is any criticism allowed. For extra stimulation for the first phase a group of 5–12 equals is assembled, given a problem, and asked to think up many solutions for it; these are tossed about among the group, for improvement and addition, with laughter perhaps, and no word of criticism then allowed. A maximum number of suggestions are sought, which will be recorded anonymously and later graded for merit, but still with weight given to *quantity* of good ones. Instruction is also given on the various poisons to creativity, and the steps to be followed, and standard checklists (¶ 592) are used to stimulate ideas and their fullest development. Everything said is recorded, and the ideas later codified, studied, evaluated, recirculated, and occasionally worked up and adopted. A followup for later occurring ideas may be useful. When used as a training exercise a question might be: What else could you do with a coat hanger? To avoid repressive memories of authority and custom, Arnold [548] when at MIT even postulated a certain other world, where conditions would be highly different, but not scientific principles; thus the students should have less fear of offering a "wrong" or foolish proposal.

[585] Brainstorming has won considerable vogue of late, in various big corporations, schools for military officers, Government laboratories, and for general students in the University of Buffalo, as a means of encouraging originality and thinking up betterments in fields of invention, business management, merchandising, and collegiate education; and there are striking tales of its success. But it has seldom been seriously applied to highly scientific matter such as Chemistry, where rare knowledge is all-important, and peer groups hard to assemble. It may be useful in those *milieux* where employed.[549] But we have found little evidence that for solving baffling problems in scientific fields it has any more of lasting, carryover value than the same number of student- and leader-hours spent on more conventional efforts.[549]

Perhaps the idea has been successfully modified to teach some originality in these fields. More anon anent it in the next chapter (¶ 616–9). In any case something of the sort is practiced in every laboratory, in the discussions within project teams, both stimulating [550] and informative, and in talks with any person thought likely able to help from his special knowledge. Criticism,[551] which the brainstormers consider so withering to imagination, is presumably less so in circles professionally devoted to origination.

[586] Our last normal recourse for getting the best of both worlds, evoking free imagination from a brain well stored with useful items and bad habits for their interconnection, is one regularly acclaimed by the students of the subject. This is to rest the conscious, and invite unconscious cerebration to do the job. It is particularly called for when, after long-continued, avid, tense striving for a solution, characteristic of good inventors, involving the emotional drive which was found necessary even for problem-solving by chimpanzees,[537] the mind has become weary and exasperated, and does nothing but ever recur to the same old plans for combination.[552] The inventor or scientist should here stop, drop it all, and engage in any recreation, go to bed, do household chores, shave, converse, almost anything that is not hard, wearisome, nor vexatious. A sudden inspiration may come; or if it does not he may turn to other tasks for days or months. Sooner or later, if he is lucky and has "done his homework," then all of a sudden, in the midst of the light activity or sleeping, or likeliest of all on awakening, he finds that he has the solution, or a good new try at it, pretty fully formulated.[553] Like leprechauns his unconscious thinking has done the work for him unbeknownst, save that occasionally he feels a premonition of imminent success. Now exhilarated, he fastens it down clearly on paper, and feels a happy relief, of victory won, but proceeds to test everything with conscious, critical mind, and may well find errors. Half of research men "purposely use some means to create conditions favorable for scientific hunches." [543]

[587] Dreaming is the time when the subconscious mind is most open to examination, and we know the exuberant, illogical fancy of dreams, and yet how they follow and work out the strongest emotional drives of the daytime, conscious mind. So in sleep, or much oftener at other times of light, extraneous activity, the subconscious or as Usher [537] would say the less disciplined and more emotional mind, works out for the inventor a solution, provided there be present the mental capacity, the needed elements assembled by study, and the emotional drive to keep turning the kaleidoscope and watching for the right combination.[554]

[588] The much desired solution, often called inspiration, hunch, intuition, or insight, may owe its success to release from the trammels of habit, as with Columbus' egg, or to the inclusion of a new element never thought of before, as with Watt's separate condenser, or to a

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[551] "With true creative thought, ideas are never thought of as right or wrong, but merely accepted as ideas." Reed, E. G.: Developing Creative Talent; *Mach. Des.* 26: 142–6, Nov. 1954.

[552] But Purdy finds a favorable effect from fatigue and pressures. Probably this means that sometimes the emotion of exasperation leads to wide leaps from the logical, provided there is enough pressure to continue despite fatigue. N 617.

[553] Ives said that his great half-tone invention came in his sleep, and appeared complete as if projected on the ceiling when he awoke. Banting's insulin came similarly; and Archimedes' *Eureka!* bath is a familiar instance. Platt & Baker, N 543, its p. 1979.

higher or better synthesis of ideas than before achieved, like Ericsson's *Monitor*. These crucial solutions may also come while at his regular *ad hoc* work, even under pressure, especially when the inventor has great interest, no expectation of distractions, a sense of well-being, and of having the confidence of others.[543]

Other Nonlogical Methods of Invention

[589] Perhaps a drug can someday be found, that will induce free association in a well-stocked mind, like the hypnagogic state on awakening. The drug's action might need to be long lasting because the work of the subconscious mind, or its endless turning of the kaleidoscope until a competent pattern flashes, seems usually to take long hours, days, or months. Alcohol and tobacco in moderation are sometimes resorted to by inventors, but probably have only their familiar relaxing effects.[540]

[590] Another way of attacking a baffling problem is Edison's famous custom of trying everything, logically indicated or not. A modern scientist, say a physicist, having a mind well furnished with principles telling him at once that most imaginable proposals are utterly hopeless, will usually sniff at this try-everything method, as a waste of time. And indeed Edison probably used it in chemistry because he had no schooling in that nor any science; in electric matters he did not use it. By the same token the try-everything method is good and used today where science is lacking. In our ignorance of how and why certain chemicals poison certain species of germs or pests, it is approved practice to test new chemicals wholesale against harmful species wholesale. Once in a thousand tries a useful discovery will be made; and each experiment costs little, especially with wholesale techniques.

[591] Kettering stressed empiricism, trying things out under working conditions, however expensive and time consuming this process. "Let the problem be the boss," he said, adding that the facts of Nature are the only authority in the world that an inventor should respect.[555]

[592] Another method of forcing the mind to try paths which habit would never think of is the *check list*, such as Osborn [547] and Von Fange [556] recommend, a ready prepared list of changes that one might make in any device, such as to put it to other uses, make it larger or smaller, substitute something else, reverse its action, combine it, etc. Or with more of logic, one could apply a *matrix*, i.e., a logical ringing of the changes, using a 3-dimensional, intellectual model probably, which expresses all the possible different combinations of the properties or ideas into which the given subject matter has been analyzed.[557]

[593] Professor Gordon, when with the A. D. Little consulting firm, conducted a regular team, reported successful but since dropped, which seemed based on the one idea of the ambivalence of knowledge, or the need of an untrammeled mind. His team almost shunned appropriate competence, comprised an anthropologist, an engineer-sculptor, a business manager, and some other engineers, and its problems were posed in the most general manner, considering not "How to make a better can-opener," but "Opening"; or not a knife, but "Separat-

ing."[558] Nicholson[559] considers the method too round-about, time-consuming, and requiring more abstract thinking than most people are capable of. (¶ 620, etc.)

[594] CHANCE, luck,[560] is a factor that seems to intrude pervasively; indeed every clever step seems to depend on happening to think of something, and every failure to put together the sufficient and known elements seems a case of bad luck. But as with all games of chance, in the long run of a lifetime the chances are evened out by multiplicity, and competence of mind, equipment and effort are sufficiently assured their reward; i.e., in the long run lucky accidents happen to the right people. For illustration, take an accident that has happened to each of us—we saw a bottle fall from a table to the floor and not break. What did this accident teach us? *Nothing!* But when a like accident happened to Pipkin it taught him an invention worth, say, a hundred millions, one by which, like as not, you are reading these words—the inside frosted bulb. Why such a difference, when this ever recurring accident happened to Pipkin? It was because he was a Ph. D. working with assistants in a laboratory for 3 years by then, trying to learn just what the accident taught him. His mind was prepared for the revelation, and so was the stage. That bottle was no ordinary one, but a light bulb, filled with dilute hydrofluoric acid, one of countless such that his laboratory team had been stubbornly trying, to find one that would be thin, and etched inside, yet remain strong enough.[561] The accidents that matter happen to those who deserve them. This is why patents are granted for invention that seemed to require a lucky accident, but refused to those requiring only logical thinking (¶ 162, 206).[562]

RETURNING TO THE LOGICAL

[595] After all these nonlogical methods, or psychological hocus-pocus, for getting the hog-tied human mind to find out the rational solution for a problem, we turn back to our usual recourse in science, strictly logical reasoning. We have been considering since ¶ 557 the very many cases where the logical method had failed. But it would not have to fail so often, if our scientific understanding were better. The laws of science, however certainly proved, are apperceived in our mind, and phrased in English, in ways that may mislead us.

[569] For instance, Claude said (ftN *539*, p. 180), it is a well-known "law" or "fact," that copper is a good conductor. Yet it is the most perfect *non*conductor, under some conditions. Again, Linde[563] proposed a certain liquid air process, but ruled it out because the lubricant would freeze. Claude reading this at once said to himself: "It won't freeze if it isn't freezable." So he cast about, picked out petroleum ether, and with it made the process useful. Then he showed the same liberated mind in using concentrated sulfuric acid as the lubricant for liquifying chlorine. Still another example, which suggests how an electronic machine, and/or Ruly English, Esperanto, or an artificial "philosophical" language might be brought to bear, or simply more carefully formulated science. Any informed person would say

[561] To be sure, the same process had been twice found before (a second treatment with more dilute acid, to round the sharp angles of the etching) but by inventors who did not realize its usefulness for a light bulb. Bright, N 229, p. 327.

that you cannot, by a single pipe, pump water from a greater depth than about 30 feet. We understand the reason, and the law is clear and unimpeachable. And yet it has been successfully broken, by putting a pump near the bottom of the well, and actuating it by compression waves, sent down the column of rising water. The law should have been phrased: You cannot draw water by suction,[564] etc. Smith said, "Practically all designers agree that a problem can be handled best by first stating it in the most accurate engineering terms possible, because the delineation may reveal clues to the solution. Beyond this point logic begins to yield to hunches." [565] GE and Gordon stress definition, in the most varied and general or abstract terms [559] (¶ 619).

[597] A still more humdrum method, and the best of all, for dealing with a problem of invention, is to look it up and find it already solved, which is probably the case with most problems seriously envisaged. Wider availability of this method of solution involves better indexing and translating services, especially to reach the Russian sources, better international contacts, an international library such as we proposed (¶ 346), an international patent office or at least patent searching (¶ 495), electronic invention to facilitate all such searching, library work, and translating (¶ 166, 500), and/or larger firms', Government or trade association laboratories (ch. 11), to conduct all-sweeping inquiries. In the also likely event that the problem has not been solved, the looked up mass of proposals and knowledge will doubtless provide information and hunches for a solution—always provided that the trammels of past thinking may be somehow eluded, by such methods as the earlier discussed.

[598] We speak of solving problems; but do we know when a problem is solved, in view of constant progress being made? We know true solution best in the best of sciences, mathematics. It is known by simplicity, indubitability, wide applicability, and it is elegant, affording the mathematician a certain esthetic pleasure.[567] The case is quite similar in physics, chemistry, and also engineering. In Kettering's laboratory a motto was posted: "This problem, when solved, will be simple, because every one we have ever solved has been simple." [555] The best solutions of a mechanical nature have a delightfully simple, logical, and basic character, and a beauty of form, seen best in shapes evolved by long experience and perfecting, such as the violin, arches, the full-rigged ship.[569] Such perfect solutions do not prevent the occasional arrival of new and better ones on radically different principles, as when the sailship begot the steamship, airplane and parachute; the arch, the curved cantilever, and the violin will yield one day to the synthetic music plant based on drawn curves (¶ 344,5).

What Sort of Minds Are Needed?

[599] We have discussed heretofore the remedies for progress inherent in the psychology of invention, and in chapters 10 and 11 the most external means, that of improving the institutions to support invention and research, especially by empowering trade associations.

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[564] It is a safe guess that the invention was actually made not by seeking to pump deep wells, nor to get around that law, but by experiments first with hydraulic activation of machines, next with compression waves in liquids, then with using these for actuating mechanisms, then with seeking all possible uses for this procedure.

Now to improve the connecting link between psychology and institutions, viz., the inventor or researcher.

[600] First we need a maximum supply of good inventors, physicists, chemists, and metallurgists. So it were logical to go into the colleges and high schools, and make sure that all potential talent receive the proper education for it. All sorts of other leaders and highly trained people are needed also, their education is partly interchangeable and to some extent may be left to their own choosing. But a youth's powers of choice are limited to what courses are offered that he has heard about, at a place he can afford to attend, so there is a vast deal that needs providing. And not only graduate education, colleges, and high schools—we know that character, personality, interests, and an inclination toward a type of career, say to be a scientist, a salesman, or an athlete, are formed largely in elementary school and family. So there is need to go even into these to insure that the precious seeds of scientific genius are saved and directed toward appropriate higher education, not crushed, stultified as so often happens. Our elementary teachers and parents may wish to help, but do not know enough, particularly for a creative child. He is *different*, he doubts, neglects, or dislikes things that to others are the obvious good, outdoor sports perhaps; so teachers, playmates, and even family unite to repress his oddities and homogenize him (¶ 608,9). "New ideas generally come from people who don't realize that the obvious is obvious." [193]

[601] But could we pick out the potential inventors, discoverers, and other creative people at such an early age? Some say that we are seeking children who when adult will ably use a well stored mind, and you cannot determine this until their mind is well stored. Yet there may be some traits of a future innovator which appear in early years, or even before his birth, given his parentage. Anne Roe,[570] a student of the psychology of occupations, especially artists and scientists, was struck by the low correlations, only about 0.3, found between interests and aptitudes, and concluded that our occupational choices are determined more by our interests than by our aptitudes, though of course both enter.[571] Aptitudes are largely inborn, but interests depend on experience, she thinks, especially on how the child was treated in his family, determining whether he will be more interested in things and ideas, or in *people* as friends and opponents. A creative physical scientist or inventor must be interested in *things and ideas*, rather than people. This division, however, resembles that of introvert versus extravert, which in turn has been found to be connected with bodily build, usually the tall and lean versus the short and round, doubtless determined at birth. The Abraham Lincoln somatotype was once found highly correlated with higher scholastic success, and there should certainly be studies made, though we have found none, on the physical build of the leaders in technical creativity. Perhaps they would be found to be especially of the tall, thin type, but many of the middle, athletic somatotype [572] (¶ 484).

[602] According to Roe's data and hypothesis the type interested in people is called forth by parents who are emotionally concentrated on the child, perhaps overprotective or overdemanding, evoking love or defensive reactions, while the thing- or idea-minded mind comes from a home where he is accepted casually or even avoided. This fits

in with a finding of others that the greatest scientists have been men who were separated [573] from their fathers, or estranged, like Louis H. Sullivan, the most originative architect. Galton and Visher [574] found that the higher ranking scientists had fathers with median age 35, and more of 47+ than younger than 25.[575] It seems clear that a boy who loves his parents, honors their wisdom, and strives to do everything expected of him, will grow up to be an excellent citizen, but hardly to be a creative scientist or inventor. To become that he must be one who questions the truth or sufficiency of what all others accept. It is his business to be dissatisfied with things as they are, and with knowledge as approved. Schools with especially authoritative traditions have likewise found that they produce few scientists.[577] But indeed all our schools repress creativity, with their usual teaching that the only problems are those posed in the textbook, these have only one correct answer, and you had better be right (¶ 609, 610).

[603] There is some disagreement about the traits of creative people. Maslow [578] names two types: Primary creativeness, which is gay, spontaneous, sociable, depends on the unconscious, and accepts his own aspects of femininity [579] or weakness, contrasted with Secondary creativeness, with its taut mind, logic, caution, controlled emotion, ordered life, and repression of all weaknesses. Despite an often high IQ, this latter type is not so creative as the Primary one. Best is a combination of the two. MacKinnon [579] says, "What seems to characterize the more creative person is a relative absence of repression and suppression as mechanisms for the control of impulses and images. Repression operates against creativity . . . because it makes unavailable to the individual large aspects of his own experience."

[604] Of course we are speaking always of the usual types, and there are exceptions from every rule. Numerous other qualities are needed also for a scientific creator,[580] but any one may be lacking if the rest can make up for it. Beside these qualities discussed, they need always high intelligence, probably 150–60,[581] education sufficient for their field, good spatial visualization, exceptional honesty, accuracy, *pertinacity*, energy, initiative, observation, curiosity, interest in picking up information over wide areas, consciousness of their own mental life, a strong ego, belief in their own density. Cattell,[582] studying the great discoverers of the past and examining 140 eminent in physics, biology, and psychology today, according to 16 standard traits of personality, found them decidedly schizothymic on average, especially the physicists, somewhat dominating, inhibited, and desurgent (untalkative), emotionally sensitive, and radical—all this agreeing with the historical and Roe findings. As Drevdahl says, "They are both introverted and bold." Rossman shows an hereditary element.[583] Szent-Györgyi stresses the discoverers' motive of curiosity and says, "We seek not truth but new truth." [584] Mellinger found the more creative engineers dislike systematic, orderly work, forget names and birthdays, are restless and fidgety, are not bothered by pressure and deadlines, but may get their best ideas then; they read widely, a prac-

[575] It has been also noted that scientists are often eldest or only children, if not about the youngest in the few cases of a large family (N 576); or having no brother less than 4 years younger, probably because the boy must be independent. Roe, ftN *601*, her p. 68.

[581] Stein & Meer agree that when opportunity is held equal among research chemists, IQ-ness does not matter above the 95th percentile. N 562, pp. 170, 1. MacKinnon found their marks falling rather low in college. ¶ 609. Getzels & Jackson stress the value of the creatives who lack highest IQ. ¶ 609. N 602, N 595.

tice some recommend for inventors, have definite artistic interests, do not spend much time outdoors, and do not believe in a life hereafter.[585] Roe says [586] that productive scientists "have a dislike for introversive and affect-associated preoccupations, except for their own research. They have a liking for the calculated risk, but it must involve nature, not people, and must not depend on simple luck. * * * They dislike interpersonal controversy." * * * Creative people in general are observed to have strong sexuality, like other introverts, but late developing among scientists. An esthetic sense is common, and schizothymic and neurotic traits are not rare, nor necessarily hurtful.[587] Offishness is common.[588] Guilford,[557] our leader for theory, seeking always to identify typical traits by factor analysis, finds in creative people a tolerance of ambiguity, willingness to accept some uncertainty in conclusions and categories, and divergent, alternative solutions. They show, too, flexibility, originality, perhaps a preference for novel ideas, though he found no proof of unconventionality; and they have fluency in expressing and getting ideas. The Air Force found its creativity best correlated with Guilford's tests for sensitivity to problems, ideational fluency, and originality.[589] MacKinnon [407] found the scientists and the patenting inventors in the same laboratories to be similar in most psychological traits, but markedly distinct in their personal "research styles," the inventors being more social, and quick with improvisations, the scientists more opinionated, methodological, and immersed in a scientific tradition. In a later study MacKinnon [579] found his 45 scientists on R&D, largely engineers, physicists, and Ph. D.'s, 12 foreign born, to be strong for the theoretic and the esthetic. They did not rank high on the concept mastery test, which depends on the rapid comprehension of abstract words: they scored 94.5 versus 156 for creative writers, creative architects 113, undergraduate students 102, engineering seniors 80.4, military officers 60.3. The most highly creative of these scientists preferred, like artists, complicated, asymmetrical drawings to simple, symmetrical ones. *All* of them were less inclined to sensation of reality, than to intuition of deeper meanings that might be present, compared to 86% of the less creative, 59% of the better engineering seniors, and 25% of the general population. In a test for introversion/extraversion the more creative were 67% introverts, the less creative 60%. The creative came from unhappy homes and would not imitate their fathers.

[605] Physical scientists in general have an average social class origin which though well above the national mean is not so high as that of the social scientists, and still less that of the humanists. Knapp [590] finds one-third of their parentage in non-white-collar occupations, another three-fifths from the lower middle class, and only 9% from the upper middle and higher class families. Requiring no capital, provided the education can be obtained somehow, nor connections, culture nor social graces, today science and engineering, like thievery, are *la carrière ouverte aux talents.* Stein [591] even found among 46 industrial chemists that the more successful had the lower status of parents, an extraordinary reversal of the usual. However, Van Zelst & Kerr [592] found scientific productivity well correlated with disbelief in equalitarian practices.

[606] The local origin of the physical scientists, likewise, is commonly a smaller town or farm, of the midwest especially, their collegiate and graduate education was widely scattered over the country, not so concentrated in the northeastern prestigious halls of ivy, and they came from public high schools. But Ph. D.'s in the physical sciences are nearly twice as numerous from the New England and Middle Atlantic States, as from the Middle West, in proportion to the graduates of their respective high schools.[593] Also their frequency goes up sharply with the size of the high school's graduating class, rising to 3.3-fold when the size enlarges from 1–19 to 100–200, to 4.8-fold for the 600–800 class, and to 11-fold for the classes larger than 800.[593] Many of our greatest inventors have been foreign-trained immigrants. Meier [594] compares the different natural sciences—physicists and mathematicians are intellectuals, typically from the top group, often ministers' sons; physicists are practically always musicians; chemists are mainly lower middle class, engineers are the least aristocratic; biologists have diverse origins. Harmon [593] compares the doctors of the different sciences as to their IQ's and high school rank. The education, parentage, occupations, and age of patentees, who are weighted in proportion to their frequency of patenting, have been studied by Rossman,[595.6] Schmookler (ftN *99*, p. 31), Carr,[597] and in a forthcoming report by Sanders. Inventors' ages will be discussed in ¶ 640.

Chapter 13

THE NURTURE OF INVENTION

[607] In our previous chapter on the psychology of invention and discovery and of their achievers, we have naturally included hints as to how things might be better directed. Now to make more explicit and complete our recommendations.

[608] First we ask further study of all these matters concerning the supreme problem, the key to the key-rack, how to invent and discover. Such studies as are being vigorously carried forward only of late, by the National Science Foundation, Air Force, Navy, Office of Education, and others, on the nature and nurture of origination and its creators. We must study to understand much better the working of the mind in these crucial occupations, what sort of people it takes, how to identify them at the earliest date, and what sorts of parents and homes produce them. (¶ 600–606). With these last as partial guides the sixth year of age is none too early to begin the tentative identification and increasing protection and care of the future physical scientist or inventor. (To be sure, he might well turn out to be some other kind of scientist, artist or other leader, but these types are precious too and need somewhat similar encouragements.) As we showed in ¶ 605,6 the social status of a future physical scientist's parents, though above average, spreads far down from the top: it was found a third of the time to be blue-collar, and three-fifths lower middle class. Such homes and parents may need [601] much financial help, advice, and encouragement if their son is to be protected from the crushingly heavy, homogenizing influences about him, to become enthused by the glamor and ideals of science, probably foreign to his home even if it be a bishop's or a millionaire's, and certainly foreign to most of his neighbors and playmates. Then he must be led on through about 19 years of increasingly costly schooling, somehow paid for. Considering what we must usually start amidst, and all the difficulties, it takes something of a miracle to create each creative person. Yet this minor miracle must become routine production of thousands of scientists and inventors each year, if we are to meet the demands of efflorescing science, exploding world population, the contest with Communism, and continue the growth rates of invention and its sciences, which raise their output 80% in each decade, and double their inputs (¶ 79 and chart 4).

[609] We have spoken (¶ 600) of how the boy who is a potential inventor or scientist tends to be bookish, aloof, peculiar, more interested in reading, or collecting stamps or rocks, perhaps, than in sports. He has probably a higher IQ than his teachers, and also an original,

[601] Roe finds that the successful scientists often as boys had hobbies, a room in which to work on them, freedom from after-school jobs, and from bossy parents, and had significant contacts. Anne Roe: Crucial Life Experiences in the Development of Scientists; pp. 66–77 of E. P. Torrance, ed.: *Talent and Educ.*, 1958–60.

imaginative, and humorous turn of mind. Such a boy is likely to make a right poor impression on ordinary teachers, so that they are less inclined to give him encouragement or recommendations, than to a normal, bright, well-to-do, industrious child who duly ingests and regurgitates the whole school diet regardless. Getzels & Jackson [602] compared the children shown by five tests to be in the top fifth for creativity, but not in IQ, with their schoolmates of high intelligence and not highest creativity. They found the creatives a humorous lot, and doing a trifle better in school achievement than their smarter opposites, but ranking somewhat lower in their teacher's preference. The high IQ's in turn gave a correlation of +0.67 between the qualities they wanted for themselves and those they thought the teacher wanted. For the creatives this correlation was *minus* 0.25—they were resigned to displeasing the teacher, more often than not, doubtless from experience, and they stuck by their discordant ideals. And they saw but little connection (+0.10) between the traits they admired and those that lead to adult success.[603] MacKinnon's [579] research scientists tended to have been honor students in high school, but unhappy there and at home. Their performance worsened in college, usually to C+ or B−, which would hardly admit them to graduate study today. They had their own interests and opinions. Torrance says that scholarships for good grades assure nothing for the future beyond good class grades; the youth's creativity may be nil.[604]

[610] This conflict or boredom with teachers and schooling is particularly unfortunate in boys who must get so much schooling to meet modern needs. Together with anti-inventive traits of engineering education (¶ 633–7) it is an explanation of the claim frequent a generation or more ago, before science became so vital for invention, that good inventors hardly needed engineering nor advanced science training, but did as well without.[605] As we said in ¶ 602, all our schools repress originality and the questioning of authority, or doubting the excellence of anything customarily approved. The only problems recognized are those that the text book calls on you to solve, and "these have but one correct answer, and you had better be right." Convergent thinking, the psychologists call it, contrasted with the divergent thinking about various possible truths or solutions, which the inventor needs and which his mind is apt for, as the psychologists find. So some propose that all our schools be shaken up, to free the children's thinking

[602] Presumably the ideal inventor would rank high in *both* creativity and IQ; but such people are rare, and are much needed for other posts of leadership. In turn, a study of how mathematics and science teachers were rated by their principals, showed in all aspects appraised, negative correlations with the teachers' tested *ingenuity*. Jex, F. B.: Negative Validities for Two Different Ingenuity Tests; in Taylor, N 600, 1959, pp. 124–7.

Among MIT students in a product design course the AC Test for Creative Ability indicated the A scholarship group to be distinctly better than the B, but the C and D were a little better than B, and included the best of all. N 613.

[603] Schmookler found his responding patentees of 1953 to be 69% college graduates; but Rossman's of 1927–9, who held 4 or more patents, were 55% graduates, and their education appeared to have no influence on the number of their patents. However, this would be more or less accounted for by the older men having less education and more years in which to accumulate patents. Smith's data of 1931 likewise showed little relation between invention and undergraduate or postgraduate education, or scholarship evidenced by Phi Beta Kappa or Tau Beta Pi. But Sigma Xi, given primarily for promise or achievement of research, raised the percent of the graduates who were inventors from 17% to 22%, and a Ph. D. to 25%. N 606.

[604] A book of a century ago on invention said science was of no use to inventors! Emile With: *Les Inventeurs et leurs inventions*, 1864. Cf. Schmookler, ftN [93]; Rossman N 595. Stevenson and Ryan wrote in 1940, that the really ingenious designers usually had come up through the shop and drafting room, not through college. N 614, its p. 673.

and creativeness, now practically restricted therein to drawing, painting, and theme writing.

[611] But to the present writer, such an educational revolution seems both too vast a labor for a Hercules, and also not what is needed for the mass of boys and girls. Some are headed for jail, almost all for routine tasks in industry or housekeeping; only a percent or two can ever become creative scientists, inventors, artists, or other innovators (¶ 576). Moderate conformity and standard information, not world-outthinking originality, is what the mass most need, and is already the main aim of all our schools below graduate level. Our logical course, would be first to identify, when we can learn to do it, the few who have a chance by their mentality and the future job supply, to become creative thinkers or other leaders. Then we must accord to these few, proper, effective educations for their precious talents, and lastly assurance of suitable work on graduation. There are many ways to further all this: the psychologic science and tests which our cited authors are rapidly improving through governmental support; elementary and high school classes graded by ability, in different subjects separately, such as Conant endorses; [607] special schools like the Bronx High School of Science, with its brilliant student body; private schools for the well-to-do, giving scholarships to some of the able less fortunate; NSF and other collegiate scholarships and graduate fellowships; all sorts of assistance to public high schools and nonsecretarian colleges, to improve their curriculums particularly in science and courses for the creative (recalling what schools the physical science men come from (¶ 606)); and income tax assistance to parents supporting able scientific students in college. But in all this supporting of education we should bear in mind what sorts of students will pay off in later life, and that selection simply on the basis of class grades, IQ, character, and being liked by the teachers, will shut out a considerable part of the original, creative talent. (¶ 601–606, 9, and ftN *603*).

[612] Finally, most basic of all, we should encourage by tax and other means parents who could beget and rear such children, to do so, instead of letting the race be increasingly taken over by the mentalities and homes less capable of science.

Teaching the Art of Invention

[612.5] Inventiveness has hitherto been practically always treated as simply a special gift that comes by nature. But the only activities that come so, without need of instruction, are such as swallowing, sneezing, and scratching oneself. Everything else needs teaching, training upon the instinctive bases; so why not the supreme profession, inventing and discovering? All fine arts, all the sciences, morals, religion, leadership, mental hygiene, all are taught in regular university and often lower grade courses; so why not the supreme art of using the mind to create new knowledge, not for the individual student but for the whole world? [603] Yet only during about the last dozen years,

[603] Guilford cites experiments indicating originality can be taught, at the expense of ideational fluency, which does not matter much except perhaps pedagogically, and for brainstorm scoring. N 557, p. 159.

practically, has it been done and but sparsely and weakly as yet. To be sure, the motive to teach a science or art is proportional to its development, perfection and power. But how does it acquire these? By being studied, taught, and used.

[613] Teaching specifically to invent is as yet almost confined to engineering staffs in a few great corporations. Instruction in chemistry, physics, and other sciences in graduate schools has long been better handled than with engineering (almost always undergraduate), through paying more attention to the methods and supreme value of discovering things, so that here less need is felt for separately teaching origination. But Kubie [609] points out that most people trained in graduate schools of science never become fully creative scientists. Children are full of free-ranging imagination, but the repressions of society, the drill and grill of schools, or masked neuroses, rub it out of most of us, sooner or later, usually sooner. We may hope that in all the sciences, as well as in engineering, the same logical course can ultimately be followed, of first identifying and separating out the creative from those more fitted to be routine practitioners, administrators, teachers, or salesmen, and then training the creatives in the art of Discovery.

[614] Due to the inspiration of Osborn's "principle of deferred judgment" [547] (¶ 584) and the psychological studies, efforts to teach creativity in general, and in artistic and less scientific lines, have become widespread lately. Guilford in 1958 wrote,[610] "I have been told there are about 2,000 courses [in creativity] being offered in universities, in industry, and in governmental agencies." The number seems questionable; and most university students in such a course would be far removed from real, economic invention or scientific discovery, especially if the enrollment were open to any student looking to fill up his time card. As Guilford says, how much creativity can be carried over from one field, say art, to a very different one, say chemistry, is a classic difficult question, and would depend on the teacher, to show art as a part of living in general. But heightened creativity could serve many other good purposes beside invention proper. General courses have been offered notably in the Universities of Buffalo, Boston, Minnesota, Nebraska, Drake, Northwestern,[616] and the Industrial Relations Center in the University of Chicago.[612]

[615] For important advancement of technology or science we should first find candidates of most potential for such a course. Much has been learned about how to test people for creativity; e.g., by the AC Test for Creative Ability [613] devised and used by GM. GE has tried all sorts of tests, and found best a true account of boyhood inventions.[614] Next best was familiarity with a wide variety of machines, because a man picks up such information as interests him.

[616] In the teaching of invention proper GE has been the leader. They began in 1937 with a system of apprenticing engineering graduates to able inventors, then moving them through departments, giving instruction in sketching, graphics, materials and methods of manufacture, and having the student carry through a big personal,

[612] A 10-session course took up the psychology of creativity, brainstorming, checklists, analytical techniques, getting one's idea accepted, and started each student on a problem from his own business. Renck & Livingston, N 613.

inventive project.[614] "Creative capacity was interpreted as a facility in the art of design",[615] but with little philosophy of invention the attention was rather on reduction to practice, than on getting the best possible problem and plan to start on, through imagination. The results were mediocre [616] save for experience, which led to the present, more imaginative, two-year course. It is given in four cities each serving the GE plants of several States, in a four-hour session each week, except in summer, beside much home work. The students are carefully selected for their psychology, interest, and success on a trial problem, rather than from reports of their college work. They are all employees in their 20's, recent graduates in engineering or physics. The instructor, who gives full time to the course, is always a recent graduate of it, to maintain *rapport* with his students, to whom he gives much individual attention. A sort of textbook is Von Fange's,[556] a former director of the course. There are guest lecturers, and many written and oral class reports. The first year is given more to the theory and encouragement of creativity, with some experimentation with brainstorming, and other techniques, use of check lists (¶ 592), training in exposition, and increasing the student's acquaintance with very many strange machines and principles. These are described by the students, and sometimes demonstrated by a model three or four made, all for the main *ideas* in each, not for the mathematical working out. This is a contrast to engineering education, which is overwhelmingly mathematical. There is also direct practice of making inventions, first at a once-a-week clip, then one in half a year, carried through to model stage, if possible according to an advance schedule for each step of the development.[617] The second year is given more to analytical physical and engineering studies, and to reducing to practice, by the cooperative labor of three or four, of an invention these choose and carry through to the last detail of manufacturing procedure, and advocacy to the management. The invention then may or may not be accepted for production by the company. Almost all the problems worked on are of interest to it.[615]

[617] At the same time the student's regular job is being rotated through half a dozen assignments, suitable to his interests, under creative senior engineers, as in the original system. Here again he is given as much responsibility for developing an invention as possible, so that he may gain confidence as well as experience, and exercise his inventive faculties while young instead of suppressing them, as has been required in the traditional jobs for a young engineer (¶ 635). By graduation he has usually started several patent dockets, finds several suitable product departments asking for his services, has good prospects for an inventive career, according to the history of the alumni,[615] and strongly endorses the course.[547]

[618] A much smaller program has been given by Harris in the AC Spark Plug division of General Motors, begun in 1953.[618] Consisting of a dozen two-hour seminars, it stresses examination [613] for entrance, brainstorming, checklists, refresher programs later, and pointing out the blocks to creativity, such as fear of making a mistake or appearing foolish, haste, lack of flexibility, habits, technicways, customary valuations. Good results were reported,[619] especially through the employee suggestion system. The better group, comprising 16 trainees, increased their suggestions 40% to 13 per man-year,

and the number accepted by 18% to 3.9, for which their compensation went up 111% to $83 per acceptance. The 12 poorer trainees increased their suggestions but not their acceptances, yet their average reward rose 138%. The untrained remainder did a little worse than before, but their rewards per acceptance were enlarged 18%, perhaps because having such a course in the factory "provides a constant awareness of the importance of creative ability".[618]

[619] Nicholson [559] says that brainstorming has been used also by General Foods, RCA Tube division, U.S. Rubber, and Ethyl Corp. *Business Week* [193] reported that creativity programs had also been recently given in B. F. Goodrich, Monsanto, Texas Co., Bell Laboratories, du Pont, IBM, Union Carbide, Dow Chemical, and Standard Oil of Ind. Add 3 M's,[620] and Westinghouse. Comparing brainstorming with the GE and Gordon programs (¶ 593), Nicholson says it is enjoyable, exciting with its wild ideas, useful to wake people up, but disorderly, develops little understanding, and needs to have its proposals carefully evaluated, which is not always done. The GE course "lays heavy stress on a systematic, four-step procedure of definition, search, evaluation, and solution. It stresses the definition of the problem in all possible ways". "Search" means finding all possible ways of solving the problem. Some evaluation takes place during the session, of a member's premises and logic. The procedure is orderly, appealing to engineers, and stresses specialized knowledge. But it has the disadvantage of a poor chance for very radical ideas.

[620] The aim of an inventing group, Nicholson says, and therefore a clue for teaching the art, should be first to avoid the single answer deadlock. We should start with due consideration of many proposed solutions, before settling, as our school books have habituated us, on the presumed one right answer. Suggestion system machinery is devoted to proving that ideas won't work (but does accept a large proportion (¶ 138)). Conferences develop endless arguments over whether a particular plan will work. If brainstorming, he says, keep the participants down to 15 or less, do not require ideas to be logical, attack *en masse*, encourage borrowing and adapting ideas, use significant, not trivial problems, but do not promise exploitation of the idea, and fit the method to the objective of the course. Brainstorming aims to develop creative attitudes, the GE course to train skills of development and presentation, and Gordon, to find an utterly novel solution.[559]

[621] More than 40 companies, Nicholson found in 1956, were experimenting with creativity building techniques, including Monsanto, IBM, Kodak, and Union Carbide, beside those above (¶ 619). R. Q. Wilson [621] adds North American Aviation, Boeing, and U.S. Steel. Several reports increased use of suggestion systems in consequence. At least they are building for the future; and they emphasized the needs for *invention* among supervisors and others, of identifying oneself with the company, and of contacting other departments.[559] Furthermore, engineering courses with some attention to creativity were being offered at MIT, Battelle,[622] the University of Pennsylvania, Cornell, Purdue, Rutgers, and many others, wrote Purdy in

[622] Battelle Mem. Inst. has been teaching something of invention proper, as a minor part of courses in more conventional aids for its tech. men, 170 memberships a year, also courses that encourage their staff to invent outside their assignments. From correspondence and N 621.

1957. Others [621] add Colorado at Denver,[623] Stanford, the Air Force, University of Ill.,[624] Carnegie Institute of Technology; [625] the latter bringing together principles of mathematics, physics and engineering, for inventors' use, and Pennsylvania State with a textbook.[626]

Instilling or Allowing Creativity in Engineering Education

[622] How far such courses in engineering schools have gone and could go, we cannot say [627]. The only theses we feel able and obliged to present here are that the traditional undergraduate engineering course almost totally omits invention, stifles the inventive gift by non-use during the years when the young engineer who has it should be using and developing it, and imparts an actual distaste for invention. Under our next subtitle (¶ 635) we shall show that this very bad start has been continued by a perverse scheduling of the engineer's later work. Yet these tragic blunders are committed with full knowledge that invention is of supreme importance, and increasingly dependent upon engineering (and other scientific) education, so that the engineering undergraduates of today, whatever their miseducation, will have to be the main sources for invention some years hence.

[623] The beginning of learning is the wish for it, an admiration for the knowledge and profession to be acquired. And yet, strangely and most unfortunately, all engineers are taught to shun the word *invent* and its derivatives as if they were dirty words.[669] The only exceptions are in connection with patenting, or bygone history. Except in patent matters, an engineer whose main work and honor are inventing had as lief call himself a tinkerer, fakir, or sage, as an inventor. He will use any substitute word in the language, suitable or not: research, development, product improvement, engineering, chemistry, creativity, anything but that dreadful word *invention*. Yet it is a perfectly good and current word in the language of other citizens, and has a meaning not accurately translated by any of its substitutes. Typically one of our quoted experts, a leader in teaching invention to engineers, never uses any form of the tabued word in his 6-page article on invention, except once "The hair-brained inventor" [*sic*] in derision. That is their idea—an *inventor* (patenting and history aside) is an untrained crack-pot, who works in his own basement and loses his shirt. How vastly better to be an *engineer* in a laboratory, lose the *company's* $100,000 on an unsuccessful project, and go right back to the drawing-board with a good salary continuing. Call me an inventor? Call me a fool and a failure! But yet that word *invent* remains an important one in the English language, without an exact substitute, of necessity used throughout this book. Teaching to abhor the word must to some extent estrange the engineer from what the word uniquely names, something that *ought* to be his dearest ambition, if born inventive.

[624] Allen [615] found one engineering dean who was definitely against invention, for his students or his graduates. For it is far safer, the dean said, to follow proven practice, than to experiment. And

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[623] H. von Hortenau teaches a semester course in the psychology, sociology, problems, and techniques of invention, with students' projects included; 1962.

[627] One method reported successful was for a professor to give certain undergraduates a summer job assisting him in research. They later became top research men, in other fields, attributed to this early rousing of their interest. Wilson, N 621, its p. 10.

even if your standard structure should fail for some extraordinary reason, you could defend yourself in that you had followed accepted principles. The engineers who run our factories, railroads, etc., are very apt to be hostile to invention, because it is the great foe of (immediate and personal) efficiency, by disrupting routines achieved, while its benefits likely inure to some other department. As engineering president J. R. Van Pelt says, and Rossman.[628]

[625] What is an engineering course like? It is almost all mathematics, which is not to be questioned, and principles of physical science and engineering, which are taught as unquestionable, and the solving of problems by means of these, problems which have only one right answer. It is analysis and "convergent thinking", the very opposite of *finding* problems, *asking* questions, getting around the laws of science, and synthesizing "divergent" answers, alternative solutions, which sum up the business of an inventor. Kettering said [629] that in school you must never fail, but "an inventor fails all the time and it is a triumph if he succeeds once;" while fear of failure ruins him. The specially competent Rossman [595] says the engineers' training gives them an exaggerated regard for precedent and supposed laws, and "By the time the student graduates any originality which he might have had has been completely stifled and suppressed." He quotes Samuel W. Rushmore, an engineer and distinguished inventor, as saying that engineers are rarely inventive by habit or disposition, and "I further believe that the colleges are largely to blame in their insistence upon rigid, soul-killing worship of precedent, and their cramming of immature minds with such a mass of simple data that imaginative power and all initiative are destroyed." And he quotes Admiral Fiske that the engineer and the inventor are two quite different men; it is very desirable when they can be united under one skin, or at least cooperate. Kettering [629] said the pneumatic tire is one of the greatest inventions, but "It isn't mentioned in any textbook in any engineering school. The reason, they say, is that we have no formulas for it. You have to study the low-pressure steam boilers because we have the formulas, but they don't make those any more."

[626] Another man said [630] "From grade school upward, native curiosity, individual initiative, and inherent inventiveness are discouraged. In terms of basic improvements in the individual's creative and inventive capacity, most college courses are prefabricated, predigested and preposterous." Simpson writes [631] more moderately, "Unfortunately, engineering education does not always prove a beneficial atmosphere for the development of such personal qualities (as an inventor requires). Engineering students get little opportunity to express their own ideas. Few engineering teachers encourage their students to initiate solutions instead of following the teacher or textbook. It does not help a student's personality and initiative if he spends his time being stuffed with facts." Two GE men wrote earlier,[614] "Whatever stimulus has been given to this creative ability in undergraduate days has come uniformly through student-professor relationship. * * * Whatever ingenuity a man may possess is often so deeply buried under a 4-year layer of erudition that it takes years for it to reappear, if it ever does."

[627] Professor Conrad of Yale wrote [616] "Under present systems many undergraduate students of electrical engineering, who possess

all the prerequisites necessary for the development of the inventive type of engineer, are shunted into undergraduate and graduate courses that are designed to equip them with methods of rigid mathematical analysis rather than to develop their natural talents. Oftentimes these courses take from 5 to 8 years of the most productive part of a student's life. When he has finished them he possesses a keen analytical ability, and a habit of depending upon his mathematical tools to solve all types of problems. He can solve difficult problems and has acquired a habit of presenting the solutions in a most pleasing manner to the instructor or supervisor who gave the problems to him to solve. But does he ever go out and find these problems himself? Perhaps once in awhile, but not often. He is kept too busy with his engineering courses to think of other things. By the end of 5 or 6 years he has become a human comptometer. But what has been done in the meantime in the way of developing his natural talents, his originality? Not much to be sure, and all the time he is growing older. He is approaching middle age and as yet he has not proved to the world that he can support himself." So he gets a job, of the uninventive type that we shall discuss hereafter (¶ 653 ff.). His electrical engineering training has been standardized to fit a standard job, as is easiest for both the college and the employer. And industry is usually minded operatively rather than creatively. If the purpose of enginering education is to train men to solve problems for industry and earn a living, we are doing well. "But if the purpose of engineering education is to develop the individual rather than to remake the man, to develop his talents rather than standardize his thoughts, then certainly engineering colleges are not doing all that they could for the talented student." [616]

[628] We seem to face a hard dilemma. Engineering schools spoil inventors, and yet must spawn a large part of them for tomorrow. About half of their graduates are going into research. A stuffing with facts and scientific rules stifles the imagination, yet is an indispensable kit of tools for an inventor. It is indeed the same dilemma we talked of earlier (¶ 579), the *ambivalence of knowledge.* What are the ways out?

[629] Certainly the teaching of science and the reverence for it cannot be thrown out for inventors, though they might probably be reduced. Even if we overdo science, Professor Kuhn says,[632] its convergent thinking, its elaborate, integrated, unquestioned structure, is essential and basic to education and to the ready, efficient working of an inventor's mind. Lacking it was the old-time "handbook engineer," who could solve only problems for which his handbook supplied method and data. We have spoken (¶ 596) of the importance of exact definitions and the sound, theoretical reasoning of truest science, to break through customary associations. R. L. Meier says that scientists make better inventors than engineers, because they are better trained at thinking algebraically, less hembound by habits. In his own science of physics Kuhn notes how fast the pace of discovery accelerated when the varying mere speculations on the nature of light, in ancient and medieval times, were replaced by Newton's firm corpuscular theory, even though this was later set aside for the wave theory of Huygens, and this in turn by the modern combination of the two. Science's daily task of reconciling facts to a rigid, standard theory

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provides the best opportunity for detecting, once in a long while, stubborn discrepancies between fact and theory, which lead to better or new theories. Furthermore, in education, Kuhn says, a class would become chaos if we freely allowed the questioning of basic principles. But if the student master these, and the principles and techniques of scientific proof, he will be in the best position later to perceive and exploit those little, crucial discrepancies.

[630] Some progress has been made since most of our authorities wrote, in the occasional appearance above noted (¶ 621) of courses in creativity, and much more in the growth of graduate education, wherein second engineering degrees have become 18% as numerous as first, and doctorates crown 1.9% of the first degrees (charts 1 and 3, ¶ 61).[632.8] With its general superiority, and its thesis work on more or less original projects, graduate engineering education is much more to the point for training an inventor, and is similar to the advanced training in physics and chemistry, which we have said has not aroused complaints of uncreativity.[633] But still there will remain a large part of the recruits for the invention laboratories who come with only B.S. in Engineering degrees; hence remains a great need for undergraduate engineering training for inventors.

[631] The only sufficient remedy both for the baccalaureate engineer inventor, and for a much better start for his fellow student who goes on to a higher degree, would be, we think, to recognize that an ordinary engineer and an inventor are two different species of men, as Admiral Fiske said. We should solve the dilemma of the ambivalence of knowledge by splitting the inventor into two men, as per ¶ 582, one an engineer with technical proficiency and the calculating, conservative and other virtues needed in that profession, and the other an inventor type, having the peculiar psychology discussed in the previous chapter, and educated throughout his university course and if possible long before that, specifically to become that most extraordinary, rare, and precious type who questions old and finds out new truths, the inventor. Perhaps also the discoverer in physical science. We do not train a preacher, a writer, and a naval officer in the same schools and curriculum, nor from the same type of youth, just because they all are to deal with people. The cooperation needed between inventor and engineer can be provided later in the laboratory, where many professions work together. And of course there is room not just for the two contrasted types, engineer versus inventor, of which we have been writing to make one point, but for the infinite gradation of types which nature and our heterogeneous schools provide.

[632] If this plan for cooperating talents be right, then our first great problem is to find good means for identifying and assigning potential inventors to college courses for their precious ilk, and if possible, to high school classes too (¶ 611). R. Q. Wilson says,[621] "In industry, it is generally recognized that approximately 50% of university-

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[632.8] Among the scientists, other than engineers, in research, development or design, a better grade reporting through the scientific societies to the National Register of Scientific and Technical Personnel, 37% held the doctoral degree, 26% the master's, 32% only the bachelor's, and 1.6% not that. In addition there were ⅓ as many administering R&D, with a few less degrees.

The physicists and astronomers in research had a median age of 36 and salaries of $11,000, chemists 39 and $10,000. N 671.

[633] President DuBridge says we should encourage postgraduate engineering study and "give these men experience with the frontiers of engineering and with the techniques of creative work," especially mathematics and theory. N 634, its p. 49.

trained scientists and engineers selected for employment are highly motivated and talented. About 20% of these, or 10% of the total, have both the ability and the desire to do creative work." It will not do simply to let the youths do their own choosing. They do not know enough about themselves and the many professions; they are liable to be swayed by their parents, who may know less; and boy and parent are liable to be attracted by the glamor (as many see it) of the profession of *inventor*. Every entrance examination, NSF scholarship test, etc., postulates that people are *not* fully competent to rate their own capabilities and select their own schooling. Logically this should apply to people aiming too low, as well as too high or in the wrong direction. President DuBridge of Cal. Tech. says [634] that the brightest high school graduates in science should not be permitted to go to the lower grade colleges; and indeed half of the National Merit Scholarship winners did choose the half-dozen best colleges.

[633] In our selecting we should bear in mind all the many and peculiar psychological traits mentioned in chapter 12, and others which Government-paid psychologists are now digging out, and particularly the facts that the boys we seek are often of middle or lower class origin, and *not* the best regarded by their teachers, and usually *not* of the highest though still of good scholarship (see ftN *603*, p. 192) (¶ 609). MacKinnon's [579] psychological tests of engineering students [635] for originality and creativity, found a 0 corelation with their professors' judgments. These latter were supposed to be on "creative originality," but correlated about 0.8 with grades, and 0.77 with faculty rating of scientific productiveness. Evidently their professors were quite unable to determine their inventiveness, and could report little more than their scholastic aptitude. So MacKinnon recommends less attention to our present tests for "engineering aptitude" and intelligence, and to seek some that will show "a relative absence of repression or suppression as mechanisms for the control of impulses and images," since these make unavailable to the inventor large aspects of his experience. He must be free to use his subconscious, which works more by symbols than by logic. An inventor needs intuitive thinking, rather than sense-perception, and learning of facts unrelated. The knowledgeable man is not just full of facts, but "has the capacity to have sport with what he knows." He can manipulate ideas. Essay-type examinations are better for revealing such, than objective tests.

[634] After selecting out such students, their instruction, MacKinnon thinks,[636] should aim at freedom. There should be a paper or other problem in every course, with some liberty to select it, and a hard goal and a strong motive. To encourage intuitive thinking we should seek common elements, principles, analogies, similes, imaginative play. We must often judge, but not prejudge, rule out of consideration. Even fantastic ideas of students should be sometimes listened to. We may find our creative students hard to get along with, but must realize that they are trying to "reconcile opposites in their nature, and (we should) tolerate large quantities of tension as they strive for a creative solution to difficult problems they have set themselves."

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[635] On 40 seniors, mostly honor students, from central California, volunteers to take the elaborate tests. Their professors' judgments were not known to the psychologists. MacKinnon, N 579, his p. 139, etc.

Better Scheduling for the Engineer's Life

[635] It is a law of nature, human as well as animal nature, that instincts must be exercised *when they appear*, not first years later, if they are to obtain fullest development. And it is an axiom of education that youth is the best time to learn to do things, by doing them, every sort of thing that does not require the greatest experience or prestige. The instincts, whatever they may be, that express themselves in curiosity, discovery and invention, begin in infancy, and can be fully developed by the day a young man receives his B.S. in Engineering. In recent years, to be sure, with the great growth of invention laboratories and of graduate study, he may well go on to a job or graduate school that will exercise more or less well his inventive faculty. But a generation ago, when the present leaders of the engineering profession were getting their start, and still in too many cases, the usual life schedule for engineers has been utterly prejudicial to invention. After the anti-inventive education, above described, his first jobs have usually been bossing a gang of workmen, or drafting,[637] testing, sales, teaching, or journeying to the ends of the earth to carry technology to Hungryland. In short he was given every simple, monotonous, hard or disagreeable job that the older, married engineers on top didn't want for themselves. So he scarcely had a chance to invent, unless perchance in Designing, until he was 30 years old or so. By that age, and with such a counter-inventive start in college, his instincts or disposition and capacity to invent, would be largely stultified for good.

[636] It is no sufficient rebuttal of these charges, to say that nonetheless most of the engineering inventions have been made by engineers. They *had* to do it, whether eager, fitted, and clever or not—for there was no one else to do it. Who but an engineer could plan a power plant? Our contention is not that anti-inventive education and job scheduling entirely destroy inventive capacity, but that they have gravely weakened it.

[637] Again we quote some writers who ought to know: Julian W. Feiss of Kennecott Copper wrote in 1957,[639] "Scientists and engineers are frequently assigned to routine industrial tasks that are better filled by technicians. One large aircraft plant, not long ago, employed in excess of 100 recent aeronautical engineering graduates on routine drafting. [Hoarding of engineers has been reported, in hope of getting contracts.] One imaginative and able young man in this position told me that he had been inking tracings for more than a year; he had graduated at the top of his class in aeronautics.

[638] "Dean J. Douglas Brown of Princeton University wisely states, 'No level of pay will satisfy a man of talent who feels that his time is wasted.' The practice of routine transfers from job to job 'To see all aspects of the company's operations may be sufficiently frustrating to cause resignation unless an effective teaching program parallels each job.' "

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[637] "Young engineers usually spend from 2 to 4 years doing drafting work. . . . This type of drudgery, professional engineers contend, could easily be done by technicians," but these "are in extremely short supply", with only 16,000 new ones trained a year, half the number of engineers. Faltermeyer, N 638.

A survey of engineers in 1946 indicated that among those who had entered the profession in 1944 ff., median age 25, 15.5% were in design, 11% in development, and 6% in research and safety eng., a total of 32.3% with a good chance at invention. Those who had entered before 1940, median age 36, were 37% in invention, etc., and of the whole profession 31.7% N 638.

[639] The routine, uncreative work has to be done by someone, and may be quite all right for a routine, uncreative trained engineer, fitted by nature for such jobs. But we should first make sure that most of those who were born with the capacity to be inventors, have been identified, instilled with the inspiring prospect, given a suitable education for an inventor (or for some equally precious function for which he was also fitted), and on graduation, usually with a postgraduate degree, that he be offered work which is inventive, honored, well paid, and assured. We do this with our military academies and officer corps. How would it be if we handled those as we have our future engineer inventors? Then the graduate of Annapolis would find his own job, which could hardly be that of naval officer. He might find work as an oiler on a merchantman, or as radioman, or yeoman, or petty officer on shore patrol, and only after 10 years or so of such work might he hope to become a naval officer.

[640] The matter of Age merits further attention (ftN *632.8*, p. 200). Invention is distinctly a matter for youth. Rossman's [595] inventors made their first invention at 21.3 years average, and their first patented one at about 27,[640] whereas other eminent men have been found to begin their activity at 24, the age at which Wechsler's [641] measurements placed the peak of creativity. Lehman's [642] counts of 554 important modern inventions, and of 40 greatest such, showed modal ages of about 33, and about 5% under 20, whereas Schmookler's [643] current patentees have a modal age of about 44, with none under 20. The higher standard of inventive achievement, the younger the ages and the narrower the age distribution.[644] Chemists, he finds, make their most important contributions when 30–34, on the average, but the greatest chemical advances were from men of 26–30. Nobel chemists published their prize-winning work at average 40, physicists at 34, and 30% percent of them before 30, medical Nobelists at 44.[645] Spooner's study [646] of Westinghouse engineers and scientists, with a modal age of 32, showed a modal age at patenting of 43, which would mean 40 when inventing, with no more patenting after 55. He concludes that ordinary invention goes best at 27–48, and outstanding successes at 26–45. Of the assigned patents of 1938 sampled by Sanders [409] 16% had inventors 20–29 years old at the time of application, and for the 1952 patents 9%. For his 1938 assigned patents 13% of the applicants were 55 or older, and 26% of the 1952 applicants (whose patents were doubtless superior to the earlier ones, as per ¶ 116). Lehman found for creators in all lines that the earlier starters averaged more and better contributions.[647] Raymond Stevens observed [648] that in his A. D. Little laboratory for custom inventing there had been a sharp rise of youth since 1940, to leave less than 12% in the age group 43–54. "If men are generally hired at 25, and need 5 years of experience to develop full value, there is left a bare 10-year period between 30 and 40 for their best original creation." The remaining 25 years before retirement should be managed, he says, with flexibly evolving practices, not rules, in order to do justice, yet place men where they can be most competent.

[640] Sanders' assigning patentees had made their first successful patent application at about age 32. Their age on receiving the *sampled* patent average 41 for 1952 patents, 39 for 1938 patents. Application for the sampled patents averaged 2 years earlier. N 409.

[644] But W. Dennis points out that Lehman's decline with age is more or less countered by his tendency to downgrade the more modern achievements. (Cf. our ¶ 522). The Age Decrement; *Ann. Psy.*, Aug. 1958; pp. 457–60.

"The ordinary procedure of subordinating youth to age in all things does not seem indicated." R. E. Wilson pointed out that some older men can become consultants, others executives, while others can still furnish the inventive drive. Schmookler [642] says a young man can hardly get a chance to invent unless he has proved his creative ability; but without a chance to invent how can he prove it? We need "to discover a method of discovering discoverers, before age dulls their edge."

[641] With all these evidences of the value of youth for invention, to make the best of the best years, as well as to exercise the instinct early instead of leaving it to atrophy, it is clear that the old practice of giving young engineering graduates every job *except* invention, so long as the job were trivial, tiresome, or disagreeable, has been a custom baneful to inventiveness. Fortunately, it has been much mitigated of late, by taking young graduates directly into invention laboratories, and by graduate training. But much more neeeds to be done, through separating out and saving the creative few among engineering students and graduates.

Suggestions on Handling Inventors in Laboratories [649]

[642] "The research scientist is very much like the next man and happy to be so treated" says Admiral Spangler,[650] *except* that we must recognize that he cannot work on schedule, and that science to him is not a job but a way of life. He makes his own rules, works himself harder than the company can work him, and usually does not make a good administrator.

[643] He acquired his profession and its ideals in a University, which is an institution far older than a laboratory, and wise and insistent on its own *mores*, especially its reverence for Truth, Credit to the Discoverer, individual Freedom of Inquiry, and Service to all mankind, not just to the profits of a corporation, nor to the fortunes or wishes of a chief. Secrist says [651] the scientist has already strong motivation, including loyalty to the company, and chiefly needs to be demotivated. He has two careers, one in the company, the other in science, and needs much contact with his colleagues in the company and out, and chance for publication. He should be paid according to his probable future value, not according to the number of his patents nor his past big successes, which may have come largely by luck, and in any case were the products of a developing situation, and of a team of coworkers, among whom it is vital that there be fullest communication, helpfulness and trust, not rivalry as to which can be the first to grab off the prize from their joint effort. Vannevar Bush [652] says, "It should not be forgotten that scientists, and professional men generally, do not put in intense efforts just to earn a good income. Beyond a point many of them care very little, really, for money and what it will do. They strive because they enjoy intellectual effort, and still more because they find their reward in the respect of those about them who are justly entitled to an opinion of their performance." A study of engineers [653] reveals rather similar traits, although one-half of them mentioned money as among the best stimulants, the same number as mentioned recognition. Marcson says,[654] "In science there is a right to recognition . . . it is also a dynamic incentive of paramount importance to him." Cf. ¶ 646.

[644] A counsel often offered to management is, take the scientific men more fully into confidence as to a company's plans and needs; also do not leave carefully worked out proposals from them quiet in the files, or floundering in red tape, instead of soon informing the proponent why it cannot be adopted, or how it might perhaps be modified.[655, 6] Be cooperative, permissive, democratic toward the inventive team, advises Thomas,[657] give credit, and don't laugh at their ideas, nor quickly squelch them, nor demand proof at an early stage. Allow the man privacy, he adds, freedom from interruptions, and a chance to attend conventions. Flexibility in the top administration is needed, and an active search for more creativity.

[645] A rather wide freedom of inquiry is needed in invention, and still more in scientific research, say Hebb & Martin,[658] though it might be abused by a small man. The great Coolidge of GE was quoted: "We give each scientist all the freedom that he is capable of using." But some direction is needed, especially for team work between men of different sciences. Many want the day to day stimulation of others, or need orders. But freedom or a private office or a higher salary, become status symbols, so that a natural underling may strive for them excessively, and waste them if wangled. If self-discipline be found lacking, a scientist's colleagues may straighten him out better than a boss.[550] Perfectionism, seeking the elegant, definitive solution (¶ 598) at whatever length, is a trait of scientists which Dean Brown says [550] must be accommodated to, like their tendency to resist authority. Dr. Bush says [652] that the title of "research director" "is a misnomer—he seldom directs anyone. He is nearer to a catalyst", or broker, bringing about hopeful combinations between men with bright ideas, who may be humble young researchers, with a staff which must be heartily for the idea, and the production, sales and financial authorities who must also be brought into agreement on it.

[646] To suit the above discussed drives of the scientist-inventor, the one-man hierarchic system of simple industry needs to be changed to a freer, colleague system, says Marcson,[654] allowing more chance for peculiar ideas. Some laboratories, says Harbison,[656] advance men on a "parallel ladder" system, recognizing two separate kinds of achievement, creation and administration. Also some scientists are unhappy if they cannot teach too, so a Government laboratory lets them.

[647] Nelles mentions [659] some laboratory poisons to creativity, including large burdens of administrative work, or keeping a man too long on a small problem, or ignoring his proposals. If he leaves for a spell of better pay in sales, he is ruined for invention.

[648] A group of inventions for inventors deserves mention and support—developing devices to revise drawings, and to turn them into machined parts, as Price [660] proposed and Itek Cp. is planning.

CITATIONAL NOTES

The method and merits of this system of CITATIONAL and DISCUSSIONAL NOTES are explained in ¶ 11. This unpatentable invention was first used in the *Sociology of Invention*, N (note) 49 below.

If you do not find a note below, it is doubtless a DISCUSSIONAL NOTE, indicated by italic numerials and "ftN," as ftN *55*. You will find such a note by its numerical sequence, at the foot of the text page where the reference appears.

1. Davis, W. H.: Our Nat. Pat. Policy; *Am. Ec. Rev., Papers & Proc.* 38:235–44. 1948, followed by discussion by Folk, Dienner, and Jewett; p. 238 quoted.

2. Michelson, E. J.: How Missile Space Spending Enriches the Peacetime Economy; survey shows that the Nation is already benefiting greatly in new goods, techniques and industries. *Missiles & Rockets*, Sept. 14, 1959, pp. 13–7.

Siegel, I.H.: Sci. Discovery, Inv. & the Cultural Environment: *PTCJRE* 4:233–48, 1960. Page 246 lists many such civil-military invs.

Pats., Trademks. & Copyrights, Rept. of the Senate Subcom'ee on Pats. etc., Apr. 3, 1961, 28 pp. Pages 4,5 give long lists of military-civil problems.

3. Venetian examples from year 1416 etc. are supplied by Mandich: Venetian Origins of Inventors' Rights; *JPOS* 42:378–82.

4. Mandich, G.: Venetian Patents (1450–1550), tr. by F. D. Prager in *JPOS* 30:166–224, 1948. *See* p. 174 for John of Speyer, and p. 176,7 for the law of 1474.

Silberstein, Marcel: The Patents of Marini, 1443–57, in *do.*, 37:674–6, 1955.

Prager, F. D.: A Hist. of Intellectual Property from 1545 to 1787; in *do.*, 26:711–60, 1944.

6. Hulme, E. W.: *Stat. Bib. in Relation to the Growth of Modern Civilization.* London, 1923, 44 pp. Valuable long-time stat. data on pats., books and other indices of technology.

8. Federico, P. J.: Origin and Early Hist. of Pats.; *JPOS* 11:292–305, 1929.

12. Vojaček, Jan: *A Survey of the Prin. Nat. Pat. Systems*, 1936; and The Changing Face of Pat. Law, in *JPOS* 30:407–15, 1948.

Bennett, Wm. B.: *The Amer. Pat. Sys.*, an ec. interpretation, 1943, pp. 73–8.

13. Our N 221, his p. 44.

14. Marine, R. E., in *JPOS*, v. 12, April 1930.

15. U.S. Senate, Judiciary Subcom'ee on Pats., etc.: *1961–2 Mgmt. Survey of . . . Pat. Office*, Attachment No. 17, p. 3; and 1961 Patent Commissioner's Report. Each year averaged 819 interferences set up, and we guess 2½ pats. per interference.

16. Data dated 1942, rec'd from C. G. D. Maarschalk, Ph. D., pat. economist. Cf. also P. J. Federico: Renewal Fees and other Pat. Fees in Foreign Countries, *JPOS* 36:827–61, 1954.

17. Hulme (N 6) p. 19, and Federico, (N 8).

18. Machlup & Penrose: The Pat. Controversy in the 19th Cen.; *Jol. of Ec. Hist.*, May 1950, pp. 1–29.

19. Van Cise, J. G.: The Trend in Pat. Provisions in Antitrust Consent Decrees; *JPOS* 41:743–77, 1959.

20. Federico, P. J.: Adjudicated Pats., 1948–54, in *Amer. Pat. Sys.* Hearings before the Subcom'ee on Pats., Trademarks and Copyrights of the Com'ee on the Judiciary, U.S. Sen., 84th Cong., 1st sess., pursuant to S. Res. 92, Oct. 10–12, 1955, pp. 176–85; prepared at the request of the Subcom'ee, and reprinted in *JPOS* 38:233–49, 1956. Design pats. are incl., and not decisions in the Ct. of Claims, nor decisions not involving validity nor infringement; all these are very minor classes. See N 19 above and ftN *21*.

22. Mayers, H. R.: The U.S. Pat. Sys. in Hist. Perspective; *PTCJRE* 3:33–55, 1959, with stat. on litigation and validation, from 1850–1957.

23. *U.S. News & Wld. Rept.:* A Vanishing American, the small U.S. inventor; Nov. 23, 1956, pp. 113–6.

24. Federico, P. J.; Preliminary Survey of Adjudicated Pats., 1929–34; in *JPOS* 18:685–96.

25. Evans, Judge Evan A.: Disposition of Pat. Cases by the Courts; in *JPOS* 24:19–24, 1942.

26. Lang, Edw. H. and Thomas, B. K.: Disposition of Pat. Cases by Courts During the Period 1939–49; in *JPOS* 32:803–7, 1950.

28. Federico, N 20, reprinted, pp. 245–9, from his study of 50 recent cases in the courts of appeals. See also the Subcom'ee's *Analysis of Pat. Litigation Stat.*, ftN *269*.

29. *Ibidem*, p. 236, and the above *Analysis*.

30. *Ibidem*, p. 244; or our table 2.

36. Patents on invs., to Americans, from *Hist. Stat. of the U.S.* and latterly from data in *JPOS* 43:417 and later. Design pats. to foreigners are negligible, if involved at all. The custom is to quote pat. stat. for single years, and to include pats. granted to foreigners, but this is less stable and suitable for present purposes than the method here used. The share of foreigners in Amer. pats. rose from 6.3% in our earliest period to 15.7% in 1957–9. Our figures are yearly averages for 3-year groups. The 1960 and '61 group average would be 41,200 pats. yearly to Americans.

37. Workers ten years old and over, for the 1880 datum, and 14 and over for 1962. From *Stat. Abstract of the U.S.*, whence many of our stat.

38. *The Rate and Direction*, N 46, esp. J. R. Minasian: The Econ. of R&D; F. Machlup: The Supply of Inventors and Inv., N 96; J. Schmookler: Changes in Industry and the State of Knowledge as Determinants of Indus. Inv., pp. 195–232; and Y. Brozen: The Future of Indus. R&D, abstracted from his Trends in Indus. R&D, N 62.

Kreps, T. J., statement on the econ. aspects of inv., with stat., in pp. 16,206–69 of U.S. Temp. Nat. Econ. Com'ee: *Hearings, Part 30: Technology and Concentration of Econ. Power*, 1940, pp. 16207–17599.

Sanders: Some Difficulties in Measuring Inventive Activity, N 97. Demolishes pats. as an index.

Stafford, Alf. B.: Is the Rate of Inv. Declining? *Am. Jol. of Sociol.* 57:539–45, 1952. Attempts to measure the course of inv. by pats., while acknowledging that these have no long-term stable ratio. A decline of inv., or its transformation to a new, incommensurable parameter, is suspected. *See also* his Trends of Inv., N 156.

Schmookler, J.: The Level of Inventive Activity; *Rev. of Ec. & Stat.* 36:183–90, 1954. Combines with advanced ec. stat., hist. data on occupations, pats., various inputs and GNP, the last 3 measured according to their variations from trend. Although respecting his competence in econ. stat., we disagree with his conclusions in this and his articles below, that the per capita rate of Amer. inventing has not advanced greatly, and that pat. applications might have some use as long-run measures of inv.

———: The Interpretation of Pat. Stat.; *JPOS* 32:123–46, 1950.

———: The Changing Efficiency of the Amer. Economy, 1869–1938; *Rev. of Ec. & Stat.* 34:214–31, 1952.

———: Pat. Application Stat. as an Index of Inventive Activity; *JPOS* 35:539–50, 1953.

———: The Utility of Pat. Stat.; *JPOS* 35:407–12, 1953. Mentions various useful considerations and ways of using pat. stat. properly, although he tends to see little decline in the percent of invs. pat'd.

Princeton Conference on Quantitative Description of Technol. Change, 1951, papers individually pub., inc. ones by Schmookler, Stafford and Gilfillan.

Markham, J. W., Worley, J. S., and Brothers, D. S.: The Value of the Amer. Pat. Sys.: an inquiry into possible approaches to its measurement; *PTCJRE* 1:20–56, 1957, esp. 49–53 on the difficulties of measuring productivity and the shares of it due to inv. and the pat. sys.

Abramovitz, M.: Resource and Output Trends in the U.S. since 1870. Nat. Bur. of Ec. Research, *Occasional Paper 52*, 1956, 23 pp. esp. pp. 7,8.

Merton, R. K.: Fluctuations in the Rate of Indus. Inv.; *Q. Jol. of Ec.* 49: 454–74, 1935.

Ewell, R. H.: Role of Research in Ec. Growth; *Chem. & Engg. N.* 2980–5, July 18, 1955. Compares stat. of R&D and Productivity, recognizing their incommensurability.

39. Hart, Hornell: Acceleration in Soc. Change, chap. 3 of F. R. Allen et al.: *Technology and Social Change*, 1957, 541 pp.; also Hart's chaps. 19 and 20.

———: *The Technique of Soc. Progress*, 1931; and Technol. Acceleration and the Atomic Bomb, *Am. Sociol Rev.*, June, 1946, pp. 277ff.

40. Calculated from *Econ. Rept. to the Pres.*, 1957, p. 124, by ratio chart trend between the dates named and 1956, in stabilized dollars.

U.S. NSF: *Revs. of Data on R&D*, No. 26, February 1961: R&D and the Gross Nat. Product, with stat. comparisons and trends.

Solo, N 670, ests. the real growth of the GNP at about 4% yearly for 1947–60.

43. Brozen, Y.: Scientific Advance as a Factor in Econ. Change; in U.S. NSF: *Scientific Manpower—1957*, pp. 7–11, esp. 8,9.

44. Productivity per man-hour, in all manufacturing, in terms of goods, not money, for 1909ff., from U.S. Bur. of Lab. Stat. Rept. No. 100: *Trends in Output per Man-hour and Man-hours per unit of output, Mfg.*, 1939–53; reproducing the estimates of Fabricant of Nat. Bur. of Ec. Res. for 1909–39, and supplying their own ests. for 1947–53. We have chosen total mfg., with weighting as of 1953. Estimates for 1880–1919 are on approx. the same basis, but are for Mining, from *Hist. Stat. of the U.S.*, 1949, table Ser. D 213–7.

45. Esp. L. Darmstaedter: *Handbuch zur Gesch. der Naturwissenschaften u. der Technik*, 2d ed., 1908; used by W. F. Ogburn: The Influence of Inv. and Discovery, in his edited *Recent Soc. Trends in the U.S.* 1:126, pub. 1933; and by P. A. Sorokin: *Soc. and Cul. Dynamics*, 4 vols., esp. v. 1: chap. 5, and v. 2; chap. 3. Tried in certain fields by J. Schmookler: Changes in Indus. and in the State of Knowledge as Determinants of Indus. Inv., in *Rate and Direction*, N 46.

46. *The Rate and Direction of Inventive Activity*: Econ. & Soc. Factors; a Conference (in Mpls., 1960) of the Universities-Nat. Bur. Com'ee for Econ. Research, and Com'ee on Econ. Growth of the Soc. Sci. Research Council; pub. by Nat. Bur. of Ec. Res., 1962; 635 pp. A valuable source; cf. N 38, 45, 57, 97, *152*, 407, 526.

48. Prepared by the author for the late Jos. Schumpeter; unpub. as yet.

49. Gilfillan: *Sociology of Invention*, an essay in the soc. causes of technic. inv. and some of its soc. results; esp. as demonstrated in the hist. of the ship. Chicago, 1935, 190 pp.; p. 96. A preliminary version was pub. serially in *JPOS*, 1934–5; and a revised and augmented ed. is now in preparation for the M.I.T. Press.

———: The Prediction of Technical Change; *Rev. of Ec. & Stat.* 34:368–85, p. 371ff.

51. Gilfillan: Inventiveness by Nation, a note on stat. treatment; *Geog. Rev.* 20:301–4. 1930. Reprinted with addl. comparison of Amer. States in *JPOS* 12:259–67.

52. Federico, P. J.: Comparative Internat. Pat. Stat.; *PTCJRE* 6: Conf. No.: 37–42 and 154–6. 1962. Pat. applications per capita.

53. Sanders, B. S.: Trends in Inv. Here and Abroad: *PTCJRE* 6: Conf. No.: 32–5 and 147–53, 1962.

56. Federally financed R&D, in stabilized dollars of 1938 value (see N 58). For 1940ff., funds provided and spent, inc. increase of R&D plant, and military pay and allowances and procurement, from NSF: *Fed. Funds for Sci. X*, table 32. Since the inclusion of mil. pay and procurement from 1953 on brought a 51% increase in the mil. cost for 1955 (acc. to ed. VII, p. 76), a corresponding increase has been made in the previous years 1952 to 1940. And since that inclusion raised the total Govt. R&D by 37% in 1955, a like increase has been added to the previous data, for 1939–1900. Before 1940 our data, of questionable comparability, are computed from *Sci. Personnel Resources*, N 84, table A–1. Intervening dates have been interpolated on the same basis with aid of V. Bush: *Science the Endless Frontier*, pub. by Office of Sci. R&D, 1945, p. 80. The 1962 calculation of the share belonging to inv. applied percentages from table 4 to the amounts from table 32. Our graph covers not only the 92% inventive but all Fed. funds for R&D, viz. 5,490,000,000 stable dollars (10,172,200,000 contemporary dollars).

57. Commercial Research. The financial contribution of private industry to organized R&D. in stabilized dollars of 1938. From *Stat. Abstract* back to 1941, and before that from Bush (see above) and from Brozen (N 60), first and last pp., with the earlier figures increased as stated in our N 60. Industrial R&D, as defined by *Fed. Funds for Sci.*, ftN*55*, covers the phys. sciences incl. Engg. and Medicine, but not market research, soc. nor psych. sci., quality control, routine testing, etc., nor capital nor pat. expenditures. Recent and future trends are discussed by Brozen: The Future of Indus. R&D, in *Rate and Dir.*, N 46, pp. 273–6, and in *Jol. of Bus.*, N 60.

58. All cost data are given in stable dollars of 1938 purchasing power, converted by the General Price Index of Snyder & Tucker for 1920–38, from *Hist. Stat. of the U.S.;* and from 1939 on, according to the Consumers Price Index for

moderate income families in large cities, with base 1935–9=100, using the adjusted basis in 1950ff., from *Stat. Abstract.* Salaries of professional researchers rose faster than this index; so these plottings of Govt. and commercial R&D funds are not used in our further computations.

Solo, N 670, p. 52, uses a special price index from E. A. Johnson & H. S. Milton: *A Proposed Cost of Research Index*, 1961.

59. U.S. NSF: *Methodological Aspects of Statistics on R&D, Costs and Manpower*, based on papers before Amer. Stat. Assn.; 1959, 132 pp., esp. W. H. Shapley: Problems of Definition, Concept, and Interpretation of R&D Stat. This book shows the shortcomings of our statistics hitherto, but provides no better.

60. Research personnel of professional grade in industrial laboratories. 1920–38 data from Geo. Perazich and P. M. Field: *Indus. Research and Changing Technology*, U.S. Work Projects Adm., Nat. Research Project on Reemployment Opportunities & Rec. Changes in Indus. Techniques, *Report* M–4, 1940, 81 pp., pp. 65 and 78; figures were increased by 20% to 1931 and 10% to 1943, acc. to the recommendation of Yale Brozen; The Econ. Future of Research and Development, in *Indus. Laboratories* v. 4, December 1953, 8 pp.; appendix used and his Trends in Indus. R&D, *Jol. of Bus.*, U. of Chicago, 33:204–17, 1960. 1920–52 data are given for indus. labs. on first p. The Perazich and Feld data were also decreased by half the employes shown as on part time in their table A–4, and by the percentages shown as nonprofessional in table A–19. 1940 data est. from Nat. Research Council's successive reports on *Indus. Research Labs. of the U.S.*; 1946 and 1950 from *Personnel in Indus. Labs.*, 1950, by U.S. Nat. Scientific Register from Nat. Acad. of Sci.—Nat. Research Council, 1952, 13 pp. 1952 and 1954 from *Stat. Abstract.* The Govt. study (N 59, its p. 13) prefers personnel to funds data. Our 1920 figure is 5,760 professional employees.

61. Chemical Researchers. Professional personnel in Chem. and allied industries, Petroleum and Rubber, here added; 1938 and 1950 data from G. Perazich: Research: Who, Where, How Much; in *Chem. Wk.*, Oct. 27, 1951, p. 22. 1938 had 11,962. 1927 est. from U.S. Nat. Resources Planning Bd.: *Research a Nat. Resource, II, Indus. Research*, 1941, 370 large pp., a good general source. P. 180 used, classifies Research Personnel by industries, for 1927 and 1938. Jan. 1954 est. from U.S. Bur. of Lab. Stat., Nat. Sci. Studies: *Sci. and Engg. in Am. Indus.*, 1955, p. 22. 1927 figure, 3,740.

62. Organized Research Professionals. Having counts only of commercial research professional grade workers at certain years. (N 60), where there are angles in our graph, we have estimated the workers in the noncommercial laboratories according to the money put up by each in the same years, before 1939, and the amounts used by each after that. Our sources listed in N 56, preferring *Sci. Pers. Resources* and N 57, and inserting our own estimates for early missing minor items. The Industrial funds befor 1939 were raised according to a later paper by Y. Brozen: Trends in Indus. Research & Devmt., *Jol. of Bus., U. of Chgo.* 23:204–17, 1960 for underrepresentation, and with an addition of 20% to have them conform to the post–1940 data. The Govt. funds were not increased for military personnel as in chart 3, until 1940 ff. The revised basis of 1959ff. was not used. Omitted from Bush were the Research Institutes which spent 5–4 millions in 1930–40. One may cf. also *Sci. & Pub. Policy*, by Jn. R. Steelman and the President's Scientific Research Bd., 1947, 1:10, quoted by Forman in *JPOS*, p. 395 (N 208). From 1940 on we used *Fed. Funds for Sci.*, and *Stat. Abstract* for the amounts of university and comrl. research performance, and the professional counts of 1941 and 1952 from *Sci. Pers. Resources* N 85, p. 15. The 1954, 1958 and 1960 counts are from U.S. NSF: *Revs. of Data on R&D*, Apr. 1962, table 6. This divides the 1960 prelim. estimates acc. to place of employment, as Fed. Govt. 41,800; Indus. 286,200; Univs. 52,000; other nonprofit instns. 7,000. Counting workers avoids the need for an appropriate historical price index. This graph is not based on those in chart 3, nor on quite the same data. The 1960 figure is the full-time equivalent of 387,000 professional grade research employees.

63. U.S. NSF: *Scientific & Tec. Personnel in Indus., 1960.* 58 pp., pp. 1 and 36.

65. Melman, Seymour: *The Impact of the Pat. Sys. on Research;* Study No. 11 of the present ser., 1958, 62 pp., pp. 27–31.

67. *Chemical Abstracts*, American papers. Our earlier data, to 1907, were counted from *Chemisches Zentralblatt*, taking the papers of apparently American authorship abstracted in this compendium of international coverage. Our rough sampling (authors beginning with H) should give results within a few percent of correct. For 1880 the international total was 2,662 papers, of which 5.9% were

American, or 157 papers. For 1892, 7.1% of 4,932; for 1900, 11.5% of 3,540; 1907, 10% of 7,570. Patents are omitted in all our counts. Continuing by a slightly different method, we reckoned authorships (not papers) from all nations, 1902–6, 4,331 *per year*; 1907–11, 7,300; 1912–16, 7,320; 1917–21, 8,180; 1922–4, 19,200; 1925–9, 22,100; 1930–4, 40,600; 1951, 25,350; 1954, 48,800. Authorships in *Indus. & Engg. Chem.* went up from 1.29 per paper in 1921, to 1.77 in 1936, to 2.11 in 1951, according to G. P. Bush & Hattery, eds.: *Teamwork in Research*, 1953, pp. 173,5. Cf. our N 68.

From 1907 on we could get better prepared data from the corresponding American international journal, *Chemical Abstracts*, supplied by their office and in articles by the editor, E. J. Crane, with graphs: Scientists Share and Serve, 29:4250–3; Growth of Chem. Lit. 22:1478–82; and Chem. Abstracting Measures a Nation's Research, 36: Aug. 4, 1958, pp. 64–6, all in *Chem. & Engg. News*; also in *Chem. Abstracts* 33:2636–9, 1955. We have applied hence the stated changing American proportion, to the yearly world total, using straight line interpolation. The American share, given in Crane: Chem. Ab., rose *from* 20.1% in 1909, to 1913, 20.7%, 1917, 43.9%, 1923, 32.1%, 1929, 27.7%, 1939, 27.7%, 1943, 30.6%, 1947, 41.8%, 1951, 36.6% and 1956, 28.4%. By 1961 it had fallen to 19.8% by our own sampling. Amer. papers of 1961, 21,900.

68. *Physical Abstracts*, of papers of apparent Amer. authorship, practically those first pub. in Amer. journals, counted by a brief random sampling method, with a Probable Error of several percent, say +4%. The Amer. and all papers were counted on enough randomly selected pages to yield never less than 14 and usually 30–40 Amer. papers. Then the Amer./foreign proportion was applied to the total papers of the year as in table 3 following.

Using what comprehensive abstracts have been published in English, the years 1894–7 come from *Abstracts of Physical Papers* from Foreign Sources, pub. by the Physical Soc. of London. The percentages American in the table below were corrected for the unlisted British contribution, from Fussler, cited below, his table 17 Physics. Sarell, N 107, adds much other data and explanation. Our 1894 figure is 91 Amer. papers. The years 1898–1902 are from *Science Abstracts, Physics & Elec. Engg.*, pub. in England. From 1903 on our chief international source is *Science Abstracts, Physics*, its continuation for that science. In table 3 we have added for comparison the percentage of Amer. authors, calculated from H. H. Fussler: Characteristics of the Research Literature Used by Chemists and Physicists in the U.S.: *Library Qly.* 19:19–35 and 119–43, 1949. This study is based on authorships, through subsequent citations rather than on original publication of papers, hence includes a valuational selective factor not found in our other abstracts data, and also an Amer. bias, vs. a probable British bias in our own data, and some rise from a growth of joint authorships. His varying time lags between writing, citing and abstracting have been adjusted for. Our 1961 figure plotted is 6,422 Amer. papers.

TABLE 3.—*Abstracts of physics papers, with percentages American, 1894–1961, explained above*

Abstracting year	1894	1896	1897	1898	1902	1904	1911
Total abstracts	793	-------	787	1,443	2,244	3,669	1,785
American papers	91	-------	123	352	476	540	297
Amer. percentage	8	-------	15.6	24	28	15	17
Amer. percentage from Fussler	-------	17.4	-------	-------	-------	29.4	39.9

Abstracting year	1915	1920	1929	1939	1946	1949	1954	1961
Total abstracts	1,933	1,700	3,860	5,000	2,389	10,965	10,085	21,400
American papers	637	385	889	1,033	1,371	-------	3,051	6,420
Amer. percentage	33	23	23	20	48.3	-------	30.3	30
Amer. percentage from Fussler	44.7	46.4	49.6	55.9	-------	41.5	-------	-------

69. Electrical Engineering Abstracts, from *Science Abstracts, E. E.* Our own count of Amer. papers, as we have told for Phys. papers. Those for all countries in 1903 were 1,120; in 1904, 2,725, 40% Amer.; 1913, 1,380, 36% Amer.; 1922, 1,155, 47.4% Amer.; 1931, 2,565, 32% Amer.; 1938, 7,203, 20.4% Amer.; 1949, 3,764, 31% Amer.; 1955, 5,046, 33% Amer.; 1960, 8,537, 29.1% Amer., viz. 2,485 Amer. papers.

70. *Engineering Index.* Abstracts of Amer. papers in this international series pub. by ASME since 1918, preceded by J. B. Johnson's series of less but growing coverage. The starting count, 775 papers, is the yearly average for the vol. covering 1884–91, and is plotted for the midpoint, 1887.5. Similarly for the next vols., 1896–1900 and 1901–1905, after which came other editors and single year volumes. The Amer. and foreign papers were sample-counted for the years up to 1905 and for 1907, 1914, 1919, 1926, 1935, 1943, 1952, and 1961; for the other years since 1907 the total papers were reckoned and the Amer. share est. by interpolation. Final figure 16,460 Amer. papers.

72. Engineering Students, in professional courses, from U.S. *Biennial Survey of Educ.*, 1900–1954. Previous figures were est. from data of B. B. Burritt: *Prof. Distrib. of Coll. & Univ. Graduates*, U.S. Bur. of Educ. *Bull.* 19 of 1912, p. 143, for the ultimate profession of graduates of 37 colleges, assuming that his destined engineers continued the same ratio to the Engineering students in college as in 1900, when it was .0495. Data smoothed. 1954–60 from W. E. Tolliver and H. H. Armstrong: Engg. Enrollments & Degrees in Institts. with ECPD Accredited Curriculums: 1960; in *Jol. of Engg. Ed.* 51:470, increased by 4.4% to consist with prev. 1954 fig. for all engg. students. 1960 figure 248,000 students.

73. Engineering doctorates. 1927–35 from Nat. Research Council, *Reprint & Circ. Ser.* 1936–49 from *Biennial Survey of Educ.* 1950–9 from Nat. Research Council, Office of Sci. Personnel, for NSF: *The Sci. Doctorates of 1958 & 1959*, p. 25. 1960, 1961 from *Stat. Abstract.* 1961 figure is 1,009.

74. Chemical and Physical Doctorates. Ph. D.'s conferred in Chem., from *Stat. Abstract* and from *Sci. Doctorates*, N 73; earlier from *U.S. Biennial Survey of Educ.;* J. E. Zanetti: Census of Grad. Research Students in Chem., Nat. Res. Council, Reprint & Circ. Ser. v. 54, 1924; C. J. West and C. Hull: *Doctorates Conferred in the Arts & Scis. in Amer. Univs.*, same ser., Nos. 42 and 105; 1898–1912 from *Science*, Aug. articles of those years. Phys. doctorates also from U.S. Bur. of Labor Stat. *Bull.* No. 1144: *Employment Outlook for Physicists.* For both scis. in 1954–61 *Sci. Doctorates* and *Stat. Abstract*, as in N. 73. 1898 figures: 27 in Chem., 11 in Phys., both probably unduly small in the earliest years, when Americans often got the degree abroad.

77. Blank, D. M., & G. J. Stigler: *The Demand & Supply of Scientific Personnel;* Nat. Bur. of Ec. Res., 1957, 200 pp., using census data on professions, p. 5.

79. Chemists; 3-year moving average, annual, from data furnished by the Soc. 1961 figure, 93,637 memberships.

80. Physicists; 3-year moving average for 1918–54. From Amer. Phys. Soc.'s *Bull.* 30:15, October 1955, and from correspondence. 1962 figure is 18,570.

81. *Eng. Societies Yearbook*, 1948, and later data come from Engrs. Jt. Council and IEEE. There is doubtless some duplication between memberships, and inclusion of some foreigners, about 1–6%, exc. in the AIME where they have risen to 18%, and omission of many engineers who are members only of the specialized societies, as of motion picture or refrigeration engineers, esp. in modern times. 1960 membership, 302,850.

82. The Nat. Sci. Foundn's Deutsch & Shea Research Rept. (NSF 60–62) estimates 875,000 engineers for January 1961. For 1960 the Nat. Register of Scientists found 20,882 Physicists, 53,071 Chemists, and 29,315 Engineers. NSF: *Sci. Manpower Bull.*, April 1962. Cf. also Engrs. Jt. Council, Spec. Survey Com'ee: Demand for Engg. Grads. in 1956; *Elec. Engg.* 75:886–9, 1956.

Scientists and engrs. increased to 16-fold in 1870–1910, and to 85-fold by 1950, acc. to *Sci. & Personnel Res.*, N 74, pp. 6,7.

84. U.S. NSF: *Scientific Personnel Resources*, 1955, 86 pp. p. 7 and table A–4.

85. U.S. NSF: *Sci. & Engg. in Amer. Indus.*, Final rept. on a 1953–4 Survey, prepared by Bur. of Lab. Stat., 119 pp. Table A–14 used here. Also in N 84, p. 14.

86. U.S. NSF: *Revs. of Data on R&D*, August 1961, p. 4.

87. U.S. NSF: *Scientific & Tec. Personnel in Amer. Indus.*, rept. on a 1959 Survey, 66 pp., p. 21.

89. Chemical Patents, by U.S. to all nationalities, from Stafford (N 156 pp. 507, 517) and by correspondence. His chem. patents embrace 39 Pat. Office classes, incl. petroleum and rubber. 1916 granted 5,632.

90. Papers by Americans per year, in all pertinent sciences and Engg.; last figure on the solid line is 52,735 papers. The dotted line shows the presumed course had mil. secrecy not supervened.

96. Machlup, F.: The Supply of Inventors and Inventions: in *Rate* etc., N 46, pp. 143–67, and in *Weltwirthschaftliches Archiv* 85: No. 2, 1960.

97. Sanders, B. S.: Some Difficulties in Measuring Inventive Activity: in *Rate* etc., N 46, pp. 53–77, p. 57 ftN.

100. Writing for the L.A. patent attorneys, he objects to Melman's (N 65) use of counts of engineers and scientists to measure invention. But not successfully, since his only statistical evidence is their record of 72% of invention originating with engineers and scientists. R. F. Carr: Our Patent System Works, a reply to the Melman report, *PTCJRE* 4:55–76, 1960, pp. 64, 5; or in *JPOS* 42:295–326. Cf. ftN 220.

102. The rates of growth, usually doubling or faster in each decade, of a large number of inventions of the generation before 1930 are supplied by Ogburn: Influence of Invention, assisted by Gilfillan, N 45.

103. Kreps, T. J., statement on inv. to the TNEC, *Hearings*, Pt. 30, Technology and Concentration of Econ. Power, 16209–69, Apr. 8, 1940, p. 16212 etc. Also Brozen, N 60 and ¶ 390.

107. Sarell, M.: Variations in the Growth of Mod. Research. Well compares statistically, with some explanations, the growth of Physics discoveries in U.S., Brit., France, and Ger., by quinquennia, from 1801 to 1900–25. Mim. paper bef. Amer. Sociol. Assn., 1960. J. Hopkins Univ.

108. On a steam-boiler, Apr. 21, 1830.

109. Data of 1959 from publication of Nat. Assn. of Suggestion Systems, 25 E. Jackson, Chgo. 4. Cf. also Z. C. Dickinson: *Compensating Indus. Effort*, 1937, chaps. 18 and 19 on individualist and collectivist sug. systems.

110. Rossman, Jos.: Stimulating Employees to Invent; *Ind. & Engg. Chem.* 27:1380–6, 1510–15; 1935. "Very few (pats.) have resulted from this means," p. 1510. The only proportion he cites is not more than five pats. out of 4,000 suggestions to GE.

111. *N.Y. Times*, Feb. 20, 1955, sec. III, p. 1, cited by Schmookler, ftN *99*.

112. Wilson, Robt. E.: Looking toward the Future of Inv.; *Centennial Celebration of the Amer. Pat. Sys., 1836–1936, Proc.* pp. 20–7; pp. 21,2 used here, rev'd in Schmookler: Pat. App. Stat., N 38. Cf. also our ¶ 81.

119. Our N 214, his p. 95. All large company patent holdings are available in Study No. 3, N 138.

120. Brown, B K..: The Amer. Pat. Sys. Aids Chem. Indus.; *Ind. & Engg. Chem.*, Indus. ed., 31:580–4, 1939, p. 583.

121. Andrews, D. D., & Newman, S. M.: Activities and Objectives of the Office of R&D in the U.S. Pat. Office; *JPOS* 40:79–85, 1958, with bib. Followed by Lanham, B. E. & Leibowitz, J.; Classification, Searching & Mechanization in the U.S. Pat. Office, in *do.* 86–109. And see Pat. Office rept. for 1959, *JPOS* 42:152–6. Also *Pats., Tr-mks & Copyrights*, Sen. Rept. No. 72 of the Senate Subcom'ee on Pats., etc., Feb. 18, 1957. And N 204.

122. *Science Doctorates*, N 73; and Blank & Stigler, N 77, p. 78.

123. Quoted by Frost (N 221, his p. 54 n. 223), from *McClain* vs. *Ortmayer*, 141 U.S. 419, 426 (1891).

124. Machlup, N 177 p. 63.

125. Machlup, F.: Pats. and Inventive Effort: *Sci.* 133:II:1463–6, 1961. Stat. comparisons of the two. Replies Sept. 8, pp. 637ff.

126. Spencer, Richard, narrated and deplored the decline of patenting, thinking of it as our only means to secure invs. Let's Encourage Our Inventors; *Harv. Bus. Rev.*, May–June 1956, adapted in *Read. Dig.*, November 1956, pp. 205,6,8,9.

The Crisis and Inv., adapted from *Sat. Eve. Post* in *JPOS* 39:699–719, 1957.

127. Bachmann, O. J., Scherer, F. M. *et al*: *Pats. and the Corp.*, a Rept. of Indus. Tech. under Changing Pub. Policy; 2d ed. 1959, 195 pp., p. 138; see N 461.

128. Celler, Emanuel, Chmn., House Judiciary Com'ee, *in* Pats. and Monopoly, *JPOS* 38:49, their note 32, 1956.

129. *Sci. & Engg. in Am. Indus.*, N 85, p. 83, based on repts. from 93% of the industries named and 53% of all industries.

130. ¶ 431. Cf. also graph 3 in stabilized money, covering all R&D except that by universities, etc.

132. Sanders, B. S.: The Pat. Utilization Study. With assistance of Jos. Rossman; *PTCJRE* 1: 74–111, esp. 93, 1957. Although a preliminary study, data are very solidly established on the utilization of invs., assigned and not, pat. by Amer. inventors, for 3 dispersed recent years, with considerable further data on the same, supplemented by mim. data of June 1957, and Sanders, N 166.

134. Jewett, F. B.: Are Pats. Suppressed?; in N.Y. *Jol. of Commerce: The Pub. Interest in a Sound Pat. Sys.*, a symposium, 52 pp., 1943, p. 31,2.

135. Vaughan, F. L.: *Economics of our Pat. Sys.*, 1925, 303 pp.

136. Kaempffert, W.: Our Defective Pat. Sys.; *Outlook* 101:548–51, 1912; and Systematic Inv., *Forum* 70:2010–18; and Inv. by Wholesale, 2116–22, 1923.

137. "The Oldfield Hearings of 1912 brought out the fact that only 1% of the inventors whose names are reported in the Pat. Office are financially successful". Rice, N 142, p. 386.

138. *Distribution of Pats. Issued to Corporations (1939–55)*, Study No. 3 of the present series, by P. J. Federico, 34 pp., p. 12 and 2. Repub. in *JPOS* 39:405–53. The 1955 figure is for pats, to Americans only; foreign corps. rec'd 4.3% of all Amer. pats.

U.S. Temp. Nat. Ec. Com'ee: *Hearings, Pt. 3, Pats, Proposals for Changes in Law & Procedure*, pp. 835–1148 with good stat., Jan. 1939. P. 1127 for ¶ 116.

141. From interesting graphs measuring various traits of pats. in Pat. Office Ann. Rept. for 1954; in *JPOS* 36:772; or in *Amer. Pat. Sys.: Hearings* before the Senate Subcom'ee, 1955, 361 pp., p. 194 etc.

142. Fenning's testimony is quoted by W. B. Rice: Decay of our Pat. Sys., *Brooklyn Law Rev.* 5:357–88, 1936, a highly critical article, pp. 382.3, from *Hearings* before the House Com'ee on Pats., 1935, on H.R. 4523, 74th Cong., 1st sess., p. 658.

144. Sanders, B. S.: American Inventiveness vs. Foreign Inventiveness; *PTCJRE* 5:114–29, 1961, esp. tables II, IV, V.

145. Sanders *et al.* N 165, table 1.

146. Federico, P. J.: *Renewal Fees & Other Pat. Fees in Foreign Countries;* Study No. 17 of the pres. ser., 1958, 40 pp.; a shorter version had been pub. in *JPOS* 36:827–61, 1954. Dernburg, T. and N. Gharrity: A Stat. Analysis of Pat. Renewal Data for 3 countries; followed by Comment of B. S. Sanders; *PTCJRE* 5:340–68, 1962; to be further examined by Sanders: The Upgrading of Patented Invs., with additional insights on their comrl. use here and abroad, in a forthcoming issue of *PTCJRE*, 1963 or later.

147. U.S. reissue pat. 18,122, in 1931. His invs. are described in Gilfillan: *Inventing the Ship*, a study of the invs. made in her hist. between floating log and rotorship, (a self-contained but companion vol. to his *Sociology of Inv.* N 49; Chicago 1935, 294 pp. 80 ils. Pp. 211–30.

148. Stedman, Jn. C.: The Merger Statute: Sleeping Giant or Sleeping Beauty? 52 *NW. U. Law Rev.* 567–617; 605 cited.

TNEC *Hearings, Pt. 3*, N 138, p. 893ff.

149. *Corporate Director* 6:No.16, 1957.

150. *Sci. & Engg. in Am. Indus.*, N 85, p. 15.

151. Kettering, C. F. in TNEC *Hearings*, N 38.

153. Jewett, F. B., in *Hearings*, pt. 2, N 299, p. 974; quoted in Frost, N 221, p. 17, his note 55.

154. Adelman, M. A.: The Measurement of Indus. Concentration; *Rev. of Ec. & Stat.* 33:269–96, 1951.

Nutter, G. W.: *The Extent of Enterprise Monopoly in the U.S., 1889–1939*, 1951, 169 pp.

Stigler, G. J.: *Five Lectures on Econ. Problems*, 1949, lecture 2: Monopolistic Competition in Retrospect. *See also* N 427.

155. Gilfillan: *Sociol. of Inv.*, 1st ed., N 49, pp. 101–19.

156. Stafford, Alf. B.: Is the Rate of Inv. Declining? (N 38), p. 540; U.S. data from pat. applications; and the foreign countries from Stafford: Trends of Inv. in Material Culture, a stat. study of the classwise distribution of inventive effort in the U.S., as determined by pats. granted during 1916–45. U. of Chicago dis., unpub., 1950 617 pp. A great compendium of information and stat. reasoning, partly pub. in his other writings, e.g., his Recent Tec. Trends in Relation to Man, *JPOS* 34:292–9, 1952. The internat. stat. are from his Trends of Inv., p. 163.

158. See our disc. of Govt. patenting in ¶ 127ff; and Forman N 208, p. 402. Total outstanding pats. in 1954 were 597,233.

159. Sagendorf, K.: Uncle Sam's Billion Dollar Pat. Pool: *Coronet* 40: 138–40, July 1956.

160. Palmer, A. M.: *Pats. and Nonprofit Research*, Study No. 6 of the present series, 1957, 66 pp., p. 42. Cf. our ¶ 445.

161. Est. from data supplied by Marcus A. Hollabaugh, for the end of 1956.

163. R. F. Carr has made a similar statistical study, but by methods that seem unreliable. Cf. N 100 and FtN *220*.

164. Markham *et al.*, N 38, have a study without stat.

165. Sanders, B. S., J. Rossman and L. J. Harris: Attitudes of Assignees toward Patented Inventions; *PTCJRE* 2:463–505, 1958. Page 472 and tables 14 and 17.

166. ———: The Economic Impact of Patents; *PTCJRE* 2: 340–62, 1958. Cf. also: *Patents & the Corp.*, N 127.

167. Sanders, B. S.: Sources and Uses of Patented Inventions; *PTCJRE* 5:Conf.No., 25–27, 108–15, 1961.

168. Tuska, C. D.: *Indep. Inventors & the Pat. Sys.*, Study No. 28 of the pres. ser., 1961, 40 pp., esp. 4.6 and 5.7. Case No. 82 was omitted because of anomaly and obscurity.

Kahn, A. E.: The Role of Pats.; chap. 8, 39 pp., in J. P. Miller, ed: *Competition, Cartels and their Regulation*, 1962, p. 320 for ¶ 132.

169. Rudy, S. J.: Pat. Asset Evaluation; *JPOS* 37:571–607, 1955, schematizes the subject from the viewpoint of an individual corp., and provides a bib.

Toulmin, H. A.: What are Pats. Worth?; *Jol. of Accountancy* 47: 291–6, 1929.

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170. Federico, P.J.: Distribution of Pats. Issued to Corporations (1939–55), Study No. 3 of the pres. ser., also reprinted in *JPOS* 405–53, June 1957. Lists all 394 corps. holding (with their subsidiaries) more than 100 pats., and 244 others, with the number of pats. to each, and discusses, tabulates and graphs the matter. *Moody's Indus. Manual* for 1957 was used for all other data save numbers of pats. Royalties are for 1956, save U.S. Rubber, 1952, Sylvania 1953, and Libby-O–F 1955, the latest given.

Markham, N 38, partly approves royalty data.

171. These averages are derived from the original rept. data.

172. Melman, N 65, p. 33.

173. Bachmann, N 127, p. 159.

174. *Stat. Abstract*, under Research & Development Expenditures.

177. Machlup, F.: *An Econ. Rev. of the Pat. Sys.*, Study No. 15 of the pres. ser., 1958, 89 pp., p. 3.

179. "What is the difference between discovering a gold mine . . . and discovering a new composition of matter? . . . None. Yet one of the two gets a property right in perpetuity, and the other gets a right limited to 17 years." Jn. H. Wigmore: The Pat. Monopoly, How It Differs from Trade Monopoly, pp. 24,5, in *Pub. Int.*, N 134.

185. "An inventor deprives the public of nothing which it enjoyed before his discovery." Quoted further from *U.S.* vs. *Dubilier*, 289 U.S. 178, 186 (1933) by Frost (N 221) p. 21, note 69.

186. *Writings & Speeches of Danl. Webster*, 15:438, quoted with approval in *Pub. Int.*, N 134.

187. Benham's many-sided praise of the pat. system is quoted by Arnold Plant: The Econ. Theory Concerning Pats. for Inv., in *Economica* n. s. v. 1:30–51, 1934, p. 44, without cit. of source and is copied in our ¶243.

188. In the electric field, where duplicate inv. has been esp. conspicuous, cf. W. T. O'Dea: Elec. Inv. & Reinv., Newcomen Soc. paper of March 13, abstr. in *Nature*, 145:771,2, 1940.

189. Ogburn, Wm. F,: *Social Change*, 1922, 1950, or with Dorothy Thomas: Are Invs. Inevitable?, *Pol. Sci. Q.* 37:93–8, 1922.

190. Van Deusen, N 204, p. 135 cited.

191. Gilfillan: The Root of Pats., or Squaring Pats. by their Roots; *JPOS.* 31:611–23, 1949, explains why the old theory hangs on, in p. 613.

192. Rossman, J.: Pat. Policies for Employees; *PTCJRE* 6:Conf.No., 24–9, 1962. A continuing study, p. 28.

193. *Bus. Wk.*, Oct. 22, 1955, pp. 112,6,8, How to Keep Ideas Coming; tells of the most effective rewards for inventors proper.

194. This whole subject we have more fully developed in the article cited in N 191.

195. Edwards recommends the econ. treatment of pats., N 252, his p. 238.

198. Gilfillan: *Soc. of Inv.*, N 49, p. 60.

200. Kottke (N 211) points out this and other obstacles to publicity, p. 47ff.

201. Wilson, Robt. E., Research and Patents, Perkins Medal adr., in *Indus. & Engg. Chem.* 35:177–85, February 1943, and *Technol. Rev.* 45:307 ff., p. 494.

202. Melman, N 65, p. 34,5.

203. Vernon, Raymond: *The Internat. Pat. Sys. & Foreign Policy*, Study No. 5 of the pres. ser., 1957, 52 pp., p. 18.

204. Andrews *et al.*, N 121.

Van Deusen, E. L.: The Inventor in Eclipse; *Fortune* 50:132–5, 197–202, December 1954; p. 198 cited.

Folk, Geo. E.: Discussion; *Am. Ec. Rev. Proc.* 38:245–51, 1948, approving proposals of W. H. Davis in *do.* 235–44, Our Nat. Pat. Policy.

Perry, Jas. W. & Kent & Berry: *Machine Literature Searching*, 1956, 162 pp. Rev. in *JPOS* 38: 591. Pat. Lag., N 304.

205. Sagendorph, K.: Uncle Sam's Billion Dollar Pat. Pool; *Coronet* 40:138–40, July 1956.

206. Ericson, W. L. & I. M. Freedman: Publication in Lieu of Pats.; defensive patenting and the welfare of the pat. sys. *Geo. Wash. Law Rev.*, 26: 78–97, October 1957.

207. Hamilton, Walton H.: *Pats. and Free Enterprise.* U.S. Temp. Nat. Econ. Com'ee Monograph No. 31, 1941, 179 pp. A notable work. P. 118 says Ford had licensed 92 pats. P. 128 for ¶ 263.

208. Forman, H. I.: U.S. Pat. Ownership Policy and Its Adm. Implications; *JPOS* 38: 380–424. 478–518 and later, 1956, 1957. Repub. as *Patents, Their Ownership & Adm. by the U.S. Govt.*, 366 pp., 1957.

Kottke, in N 211, p. 40.

209. Davis, Wm. H.: Proposed Modifications in the Pat. Sys.; *Law & Contemp. Problems* 12: 796–806; p. 800 cited.

210. *Pats., Trademarks & Copyrights*, Senate Rept. No. 1430, Judiciary Com'ee, Subcom'ee on Pats. etc., Mar. 31, 1958, 31 pp., pp. 7 and 13. *do.*, Rept. No. 97, Mar. 9, 1959, p. 14. Both on Sen. bill 2277.

211. Kottke, F. J.: *Elec. Technology and the Pub. Int.*; a study of the nat. policy toward the development and application of invs., Amer. Council on Pub. Affairs publ., Washington, 1944, 199 pp., bib. An excellent source on the mod. way of inv. and patenting. Page 45 quotes the Fed. Communications Comn., on such patenting to force pooling.

214. Melman, N 65, p. 61

Dirlam, J. E.: Pats. & Progress: Is Our Pat. Law Obsolete?

Duns Rev. 69: 52–4, 90–99, April 1957, p. 96 cited. Shows with ample evidence the decline of patenting, and discusses some reasons and remedies.

215. Stedman, Jn. C.: Inv. & Public Policy; *Law & Contemp. Problems* 12: 649–79. Answers most erroneous claims for pats., while defending their general utility, and portraying the pat. situation with information and good suggestions. Page 654, etc. For ¶ 496, p. 658.

216. Reik, R.: Compulsory Licensing of Pats.; *Am. Econ. Rev.* 36:813–32, 1946; p. 829.

217. Principles 25 and 34 in the author's *Sociol. of Inv.* (N 49).

221. Frost, Geo. E.: *The Pat. Sys. & the Mod. Econ.*, Study No. 2 of the pres. ser., 77 pp. Pages 21,2 and esp., 19 his note 67.

223. Condemnations of this assumption are quoted by Machlup, N 177, p. 29, and M. Polanyi impugns the first 4 in Pat. Reform, a Plan for Encouraging the Application of Invs.; *Rev. of Econ. Studies* 11: 61–76, 1944, p. 70,1. A good treatment of this and our 3d and 4th premises is Ways to Improve the U.S. Pat. Sys., in *Electronics* 11:9ff, May 1938, by an unsigned inventor-mfr. Cf. also our ¶ 292ff.

224. This assumption, in differing words, the writer owes to Alf. E. Kahn: Fundamental Deficiencies of the Amer. Pat. Law; *Amer. Econ. Rev.* 30:475–91, 1940, p. 478 cited. This author states 3 further assumptions, resembling parts of our Nos. 5 (again), 6, and 11.

226. Amer. Assn. for Adv. of Sci., Com'ee on Pats., Copyright & Tr-Mks, Jos. Rossman Chmn: *Protection by Patents of Scientific Discoveries*, Occasional Rept. No. 1, January 1934. But the Com'ee on Intellectual Cooperation of the League of Nations approved patenting, in a report by F. Ruffini; *Nature* (London) Apr. 26, 1925, pp. 593–5.

227. Seaton, A. E.: Some Notes on the Importance of Research in Marine Engg.; Instn. of Nav. Arch. *Transac.* 60:49–56, 1918, cites various examples, *here* p. 53.

228. Cole, R. B.: Pat. Prospecting in Old Co. Files Turns up Usable Ideas; *Wall St. Jol.* Chicago, January 12, 1956, p. 1.

229. Bright, A. A.: *The Elec. Lamp Indus.*, Tec. change and ec. devmt. from 1800 to 1947; p. 195.

230. Sen. bill 1552; see Sen. Kefauver's speech in *Cong. Rec.* v. 107, part 5, pp. 5638–42; or acct. in *Chem. & Engg. N.* October 30, 1961; or *Chgo. Sun-Times* October 17, 1961. The provision was approved by the Subcom'ee on Pats. etc., but dropped by the full Judiciary Com'ee. The bill also attacks collusion anent interfering patents, and delay in granting, all for prescription drugs. ¶ 209 and ¶ 470.

232. E.g., Berle, Alf. K. and DeCamp, L. S.: *Inventions & Their Management*, 2d ed., 1947, 743 pp.

234. *Fortune:* War & Peace & the Pat. Sys., a good analysis of the merits of the system, with spec. attention to patent pooling and cross-licensing. 26:103–5 and 132–41 *passim;* August 1942, pp. 105, 132 here cited.

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235. Kaempffert, W., well discussed the technological obstacles in standardization, vs. inv., in Inv. by Wholesale, *Forum* 70:2116–22, 1923, e.g. p. 2118.

237. Nevins, A., and Hill: *Ford, the Times*, 1954, p. 489.

Galbraith, J. K.: The Mystery of Henry Ford; *Atlantic* 102:41–7, March, 1958.

238. Cranebrook, A. V., in fin. sec., Chicago *Sun-Times*, Oct. 28, 1957.

242. Schumpeter, J.: *Capitalism, Socialism & Democracy*, 3d ed., 1950, quoted with other economists on p. 26 of Frost in the pres. ser., our N 22.

243. Woodward, Wm. R.: Reconsideration of the Pat. Sys., as a Problem of Adm. Law. *Harv. Law Rev.* 55:950–77, April 1942. Suggests *inter alia*, several classes of patents for inventions of different orders; summarized as No. 416 in Senate Study 14, N 415.

Crotti, A. F.: The German Gebrauchsmuster; *JPOS* 39:566–82, 1957.

Naumann, H.: Utility Model Pat. Protection; *JPOS* 40:800–14, 1958.

244. Ballard, Wm. R.: Pats., Progress & Prosperity; NAM & *JPOS* 36:93–121, 1954.

245. The Foundation is in Geo. Wash. U., Washington, D.C., and publishes the *Pat., Trademark & Copyright J.* Cf. our N 132.

246. Betham, Jeremy, 1748–1832, our N 187.

249. Nelson, R. R.: The Economics of Invention: a survey of the literature; *Jol. of Bus.*, 32: 101–27, 1959.

250. Frost, N.221, p. 41.

251. Three economists who have perceived it are Machlup N 177, pp. 40, 60, 61, and 77; Joan Robinson: *Accumulation of Capital*, p. 87, quoted by Machlup; and Kahn, N 168, p. 315, pointing out the illogic of restricting use of knowledge.

252. Edwards, C. D.: *Maintaining Competition*; requisites of a Government policy. 337 pp., 1949, p. 229,30.

253. See repts, of Senate Judiciary Committee's Subcom'ee on Pats., Trademarks & Copyrights, 1956, 7: *Econ. & Soc. Basis of the Pat. Sys.:* Pat. Abuse and a Plan for Its Control, by Victor Abramson; *Trial of Pat. Anti-trust Cases*, By Leonard Emmerglick; *Effect of Corporate Size, Concentration, & Mergers upon Indus. Research & Pat. Policies*, by Murray Friedman; *Technol. & Econ. Tests in Determining the Validity of Pats. & Their Use*, by W. Hamilton & Till; and various studies dealing with Compulsory License.

Stocking, G. W. & Watkins, M. W.: *Monopoly & Free Enterprise*, 1951, 596 pp., Chap. 14, Pats. & Monop., with Suggestions, pub. also in *Vanderbilt Law Rev.* 3:729–65, 1950.

254. Vaughan, F. L.: *The U.S. Pat. Sys.*, 1956, 368 pp., p. 265 citing the Oldfield Hearings of 1912, part 2, p. 32, for our ¶ 190.

255. Study No. 15, N 177, p. 7.

257. From the Rept. for fiscal 1961, the fees rec'd were divided according to whether they seemed to relate to pats. or to the other bus. of the office (design pats., etc.). Then of the total spent 90% was ascribed to Pats., by official advice.

258. The Pat. Office occupied 450,000 sq. ft. net. presumably 660,000 gross (incl. corridors etc.), which figures we reduce by 10% to exclude nonpatent activities. Taking the present cost of a Govt. building as a low $12.50 per sq. ft. gross, deducting ¼ for depreciation and capitalizing at 3½% per annum, we get $5,900,000 as the value of the quarters used and $20,000 as the yearly capital cost, without further depreciation. Taking the cost of operating such a building as $1.40 per gross sq. ft., the yearly operating cost would be $883,000; total costs $903,000.

259. The cost of a case is from the Pat. Office, ftN *256*, p. 68. U.S. Pat. Office: *Pat. Attorneys & Agts.*, 1961, approx. total of those living in the country.

260. Estimating from data in *Mgmt. Surv.*, N 15, its p. 141, that their average net income is $15,000, and that their gross income would be 63% more, from the analogy of genl. lawyers responding to a U.S. Survey of Cur. Bus., M. Liebenberg: *Income of Lawyers in the Postwar Per.*, 1956.

261. Justice Dept., Adm. Office of the U. S. Courts: *Ann Rept.* for Fiscal 1956, pp. 61–301, containing Rept. of the Div. of Procedural Studies & Stat., pp. 107–71, and Rept. of a study conducted by the Adm. Office to determine the rela-

tive amount of time spent by dist. judges on different types of cases, pp. 173–96.

262. Mayers, N 22, gives some graphs of "Outstanding Pats. Litigated in Court of Appeals," with percents validated, 1930–55.

265. 1956 *Rept., supra*, p. 239.

266. *Ibidem*, p. 194.

268. The courts occupy 2,500,000 sq. ft., and have a management operating cost of $0.575 per sq. ft., acc. to their ann. rept. Taking the sq. ft. as gross, and estimating $15 new cost per unit, depreciation 1/3, interest 3½%, and 3.2% occupied by pat. suits, we get $28,000 as the yearly cap. cost without further depreciation, and $46,000 operating cost, total $74,000.

270. Sci. Advisory Bd., Com'ee on the Relation of the Pat. Sys. to the Stimulation of New Industries, Rept., Apr. 1, 1935: in the Board's 2d *Rept.*, September 1935, pp. 317–40, and in V. Bush: *Endless Horizons*, 1946, 182 pp., p. 151–69.

271. Ladd, D. L.: Bus. Aggression under the Pat. System; *U. of Chgo Law Rev.* 26:353–75, esp. p. 363.

272. Greenawalt, W. E.: Pats. & Litigation as Viewed by an Engr.; *Mining & Metallurgy* 18:339–42, 1934. Carson's pats. were 1149495 and 1302307.

273. Federico, N 20,p. 246, based on 50 recent cases.

274. MacLaurin, W. R.: *Inventions and Innovation in the Radio Indus.*, 1949, 304 pp., an understanding book.

275. Woodbury, D. O.: *A Measure of Greatness* (biog. of Weston), 1949, p. 206,7.

276. Levenstein in *Chem. Age* 21:329, 1927.

277. *Patents, Tr-mks & Copyrights*, Rept. No. 97 to 86th Congress, by Subcom'ee on Pats. etc. of the Judiciary Com'ee of the Senate, March 9, 1959, p. 27.

278. Baekeland, L. H.: E. Weston's Invs.; *Sci.* 41–484–92, 1915. He took still fewer pats. after 1908.

279. Polanyi, N 223, pp. 91,5.

281. Piel, G.: What Price Scientific Secrecy? Chgo. *Sun Times*, Nov. 10, 1957, sec. 2:3. By the ed. of *Sci. Amer.*

282. Machlup, N 177, p. 32 quoting Edwards, N 252.

283. *Mycalex* vs. *Pemco*, 64 F Supp. 425 (1946) D.C., Md.

284. Melman, N 65, p. 35.

285. Kottke, N 211, p. 47ff.

Melman, N 65, p. 46–8.

287. Perazich & Field, N 60, p. 47.

288. N 211, p. 47.

289. Eyre, Rich.: *A Necessary Reform in Pat. Practice.* N.Y., before 1939, 43 pp. Argues for drafting pats. to center on describing the inv., rather than on the claims.

290. 126 U.S. 1–584 (1888), and Petro, ftN *9* and *115*, and Hamilton, N 207, p. 87,8.

293. G. A. Leibtag claimed a working telephone in 1872. *Cleveland Plain Dealer*, Apr. 6, 1930, p. 4D.

294. *Encic. Ital.*, article Antonio Meucci; his here reported pat. is not to be found; his application may have disappeared from the U.S. Pat. Office.

295. Early Electric Telephony; *Nature*, 17: 510, 1878.

296. Petro, ft N *9*, p. 366 etc.

Douglass, W. B.: Who was the Original Inventor of the Telephone? *Prof. Engr.* 13: 18–21, June 1828.

297. As in the fight of Zenith against RCA.

298. Levinstein, Herb.: Chem. Invs., with spec. ref. to chem. pats.; *Chemistry & Indus.*, Oct. 11, 1929, pp. 980–7; critical of pats.; p. 986 cited.

299. U.S. Temp. Nat. Econ. Com'ee: *Hearings Pt. 2, Patents, Automobile Indus., Glass Container Indus.*, December 1938, pp. 253–834, esp. p. 460.

Cf. also Pat. Pooling and the Sherman Act, unsigned, *Columbia Law Rev.* 50:1113–23, 1950, p. 1114 and its notes 15,16.

300. Hamilton, W. H.: Is Our Pat. Sys. Obsolete? Yes; in *Am. Scholar*, autumn 1948, pp. 470–2. Answered No by C. W. Ooms *et al* in following issues.

301. TNEC *Hearings*, N 299, p. 270 etc.

Rice, Willis B.: A Constructive Pat. Law: *N.Y.U. Law Qly. Rev.* 16:179–201, 1939, esp. pp. 180–3; or N.Y.U. Sch. of Law, *Contemp. Law Pamphlets*, No. 12, 1939.

302. Russell, Bert: The Improvement of Our Pat. Sys.; *JPOS* 15:666–80, 1933, p. 669.

303. The applications exclude those not paying fees. There were 1,053 employes, Examiner Asst. and higher, on May 31, 1959, and we assume that 90% of their time was concerned with judging patents. The Comr. cites 78.5 applications disposed of per examiner asst., a congruent figure. D. L. Ladd: Comr. Ladd Revs. the Kintner Mgmt. Surv. Rept.; *JPOS* 44:363–78, 1962, esp. charts.

304. Pat. Lag, an article in *Wall St. Jol.* Aug. 28, 1961, describing the hopes of Comr. Ladd to mechanize pat. searching, says a primary examiner can now handle only 80 pats. a year, but formerly 160. *Do.* in N 479.

305. Quoted without date by Edwards (N 252) p. 218, note 45.

306. Russell, N 302, p. 670.

307. Ladd, N 271, his note 14, from the Polaroid Cp.

308. Geniesse, E. W.: *The Examination System in the U.S. Pat. Office*, Study 92 of the pres. ser., 1961, 181 pp.

310. Frost, N 221, p. 61, with reference 243 to the Subcom'ee's *Hearings*, Oct. 10–12, 1955, pp. 162, 198.

311. From Federico's data, (N 20) in *JPOS* 38:326,7, weighting equally the Appeals and Dist. Courts, for 1948–54.

312. Senate Subcom'ee on Pats.: *Review of the Am. Pat. Sys.*, Rept. No. 1464, Jan. 30, 1956, 16 pp., gives the time as 3 years 5 months; p. 6. For 1.397, pp. 2,3.

313. Forkosch, M. D.: Economics of Am. Pat. Law; N.Y. Sch. of Law, *Contemp. Law Pamphlets*, ser. 4, No. 2, 1940, 72 pp., p. 24ff. cited; same in *N.Y.U. Law Qly. Rev.* 17:157–99 and 406–35.

314. Frost, N 221, his p. 66.

315. Jewett, F. B.: Are Pats. Suppressed? Record Fails To Support Charges; *Pub. Interest*, N 134, pp. 31,2.

316. Quoted by Stern, N 321, 4th p.

317. Acc. to Folk, N 204.

318. Meinhardt, P.: *Invs., Pats. & Monop.* Lon., 1946, 352 pp.

319. Frost, N 221, pp. 28–30.

320. Bush, Vannevar: *Proposals for Improving the Pat. Sys.*, Study No. 1 of the pres. ser., 1956, 30 pp., p. 17,18 and 27,8.

321. Stern, B. J.: Restraints upon the Utilization of Invs.; *Annals of Am. Acad.*, November 1938, 19 pp.

322. Vaughan (N 254) gives a whole chapter to "Suppression of Pats." (pp. 227–60), but includes many kinds of action, with no clear case under our definition.

323. Barber, B.: *Science and the Social Order*, 1952, chap. 10.

324. Sanders, B. S., J. Rossman & L. J. Harris: The Nonuse of Patented Inventions; *PTCJRE* 2:1–60, 1958; p. 21,2.

325. *Soviet Union Rev.*, May 1931.

327. Edwards, N 252, pp. 227ff., says these companies were so charged in a named civil action then unsettled (1947). If this be *U.S.* vs. *GE*, tried in 1953 in the Circuit Court in N.J., the issue appears not to have been tried, perhaps because fluorescent production was by then sufficient. 82 Fed. Sup. 753, 1949; 95 Fed. Sup. 165, 1950; 115 Fed. Sup. 835, 1953.

Bright, A. A. & W. R. Maclaurin: Econ. Factors Influencing the Development and Introduction of the Fluorescent Lamp; *Jol. of Pol. Ec.* 51:429–50, 1943.

Bachmann, N 127, p. 60, citing Bright, N 229, p. 387, but generally rejecting the claims of suppression.

328. By Oberlin Smith who did not build it. Begun, N 114, p. 2.

329. Begun, S. J.: *Magnetic Recording*, 1949, Chap. I, Hist., p. 2.

O'Brien, Robt.: Magnetic Tape Reels off Changes in Way We Live; *Life*, Aug. 19, 1957, p. 74ff.

Hearing before the Senate Com'ee of Pats., on Renewal and Extension of U.S. Letters Pat., on S. 1301, Mar. 10, 1932, 43 pp.

331. Sanders *et al.*, N 324, pp. 39 and 7.

332. Gilfillan: *Soc. of Invs.*, N 49, chap. 5. The Hard Starting of Fundamental Invs.; examples in pp. 98–100.

333. Plessner, Max: *Ein Blick auf die grossen Erfindungen des 20. Jahrhunderts, I: die Zukunft des elektrischen Fernsehens* (the future of television), 1892, 93 pp. Remarkable prevision and detailed plans for television, sound records on glass or paper, facsimile telegraphy, writing and reading machines, using a selenium photo-cell.

Gilfillan, S. C.: The Future Home Theatre; *Independent* 73:886–91, 1912, *il.*, on wired television and home talkies, and the great importance of the former.

334. Fessenden, R.: *Deluged Civ.*, 1923, pp. 123–5 on his "pheroscope"; and pat. 1105881, Dec. 19, 1906.

336. Klemin, Alex.: Classification of Helicopter Systems; *Sci. Am.*, January 1930, p. 72.

337. Gilfillan, N 147, pp. 240–5.

338. By Plessner, N 333, in 1892, Jn. B. Flowers' machine was described in *Sci. Am.* 114:174, 1916. Fessenden's pat, application 358078, Feb. 18, 1907, is cited in his *Deluged Civ.*, N 334, p. 134; the pat. apparently never issued. The machine traced a cursive line, which could be read if one's language were suitably modified.

339. Davis, E. E.: Ears for Computers; Audrey (which stands for Automatic Digit Recognizer) can "hear" 10 numbers and 16 of the basic sounds in English; *Sci. Am.* 192:92–8, February 1955.

340. Dr. Jean Dreyfus-Graf, June 1, 1950, reporting at MIT; Dr. Hideo Seki of the radio wave research inst. of the Japanese postal ministry, Aug. 7, 1952, acc. to AP; and M. V. Kalfaian, U.S. pat. 2673893. Cf. also Computer Taught To Hear; *Sci. N. L.* 73:311, 1958; a product of MIT and Haskins Labs. Cf. Discrimination of Speech Sounds; *Jol. of Experimental Psy.* 54:358–68, 1957.

341. Northeastern University, Lincoln Laboratories, and IBM.

342. *Sci. Am.* 109:163, 243, 352 (1913). Cf. *Soc. of Inv.*, N 49, p. 96.

343. *Soc. of Inv.*, N 49, p. 96, using the author's work for W. F. Ogburn: The Influence of Inv. and Discovery, chap. 3 of Ogburn ed.: *Recent Soc. Trends*, 2 vols., 1933.

344. *Soc. of Inv.*, N 49, p. 95.

345. Borkin, Jos., & Waldrop, F. C.: *Television*, a Struggle for Power, 1938, p. 38.

346. Fessenden, N 334, and his biog. by his wife, and M. W. Sterns: In Memoriam; R. A. Fessenden; *Radio N.* 14:334,5.

347. *Inventing the Ship*, N 147, pp. 91ff.

350. Cf. Renbert & Prescott's pat. 7631, of 1850, which may not be the first.

351. *Sci. News Letter*, 75:186,7, 1959, and Post Office release of Oct. 12, 1959, mentioning exhibit of a machine that reads and sorts typewritten addressed envelopes.

352. By Alex. Bain, a Scot. Hist. in chapter 1 of the Chas. R. Jones: *Facsimile*, 1949. Brit. pat. 9745, in 1843. Amstutz U.S. pat. 1019403.

353. According to a boast of Gen. Sarnoff, quoted by J. Walker: Facsimile Much Faster, but Slow To Catch on; *Edr. & Pub.* 84:49, Mar. 17, 1961.

354. Pat. 2909600; *N.Y. Times*, Oct. 24, 1959.

355. Pierce, E. H.: A Colossal Experiment in "Just Intonation"; *Mus. Q.* 10: 326–32, 1924.

358. Cooper, F. S.: Guidance Devices for the Blind; *Physics Today* 3:6–14, July 1950.

The Experiments of Wever & Bray, e.g. using a cat's ear as a microphone, are described in *Cur. Hist.*, June 1930, p. 542.

359. Meier, R. L.: *Science & Econ. Development;* New Patterns of Living. 1956, 266 pp. But MHD, Magnetohydrodynamics, is approaching practicality in corporate hands.

360. *Sci. News Letter*, July 5, 1958, p. 15, tells of GE's Volney reaching 30% efficiency.

Wall St. Jol., July 7, 1958.

361. Jenkins, D. S.: Devmts. in Saline Water Conversion; *Jol. Am. Waterworks Asn.* 49: 1007–19, 1957.

362. Linington, R. E.: The Application of Geophysics to Archaeology; *Amer. Scientist* 51: 48–70, 1963.

363. Predictions by various scientists, esp. R. N. Shreve on salt marshes, C. C. Furnas on synthetic food, A. V. Grosse on atomic energy, etc. are pub. in *Chem. & Engg. N* 29:II: 3274,5, Aug. 13, 1951.

364. *Newsweek*, 5: 35, Apr. 13, 1935, and 5: 3, May 11, 1935.

365. *Sci. Am.* 193: 50–2, October 1955.

366. Huntington, Ellsworth: *Mainsprings of Civilization*, 1945; and his Climatic Pulsations and an Ozone Hypothesis of Libraries and History; in Univ. of Pa.: *Conservation of Renewable Natural Resources*, pp. 99–147, 1941. *Sci. News Letter* 75: 185, 1959.

367. Edwards, F. J.: Future of Quartz & Silica; Soc. of Glass Technology, *Jol.* 39:58–60, February 1955; cf. also pp. 37–47.

368. Gilfillan: *Inventing the Ship*, N 147, pp. 234–9.

369. From: *Fed. Funds for Sci., III*, N 56, p. 33, we derive that the phys. science obligations embraced 95.6% of the Fed. payments for conducting Defense R&D and that the total Phys. sci. aside from Defense was $288 m.; and from table 7 that non-Defense R&D was supplemented by $102 m. for increase of R&D plant; so we get a non-Defense total of $390 m. including building funds. Then we turn to the X ed. of *Fed. Funds*, p. 122, to obtain the Defense R&D obligations for 1954, including building *and military pay* and allowances, $2,416 m., reduce this to 95.6% for Phys. sci. only, and add it to the non-Defense obligations above derived, giving $2,700 m. We next reduce this by 5% to change from Obligations to Expenditures as in III:21:1953, and add $9 m. for OTS and pat. expenses, yielding $2,575 m.

370. *Fed. Funds for Sci., X*, p. 106 gives for 1962 anticipations, for Research only, $603 m., for physical sciences proper, and $1,348 m. for engg. scis: (part of $31 m. for math. scis. might be appropriate to add), and a quarter million for the Patent Office. There were also $151 m. for the biol., $535 m. for medical, $83 m. for agric., $70 m. for soc., $50 m. for psych. and $41 m. for other scis., a total of $2,912 m. for Research only. Assuming that the phys. and engg. proportion held also for the amended 1962 total of $10,792 m. (p. 18) including Development, plant addition and military pay, less 5% to reduce budget to expenditures, we get $6.8 billion for invention and its sciences. As an alternative estimate, we take from pp. 78,9 the gross R&D budget for the Government departments likely to work mainly for invention and its sciences; less 5% their amended R&D budget totals $8.4 billion. The average of these two estimates, $7.6 billion, is set down as our best guess.

371. Repartition according to the sources of support for higher education in general in 1951–52, from U.S. Office of Education: State of Higher Education, table G, reducing the item "fees etc." by one-half and placing it in the commercial column.

372. U.S. NSF: *Scientific Activities in 6 State Govts.*, summary rept. on a Survey, Fiscal Yr. 1954, 62 pp. Covers N.Y., Calif., Conn., N. Mex., N.C., and Wis., States which took 31% of the patents then granted to Americans. Tables on pp. 6 and 36–8; also *Stat. Abstract.*

373. U.S. NSF: *Scientific R&D in Colleges and Universities*, Expenditures and Manpower, 1953–4, 173 pp., esp. table 4, and p. 49. The work in 807 small colleges and universities proper was added to that of the 173 which did almost all.

374. Funds for R&D in Engg. Schools, 1953–4; No. 7 of NSF: *Rev. of Data on R&D.*

375. Of their patents only 67 were under the exclusive licensing arrangement likely to be of the commercial, monopolistic nature. For 1954, from Palmer, N 160, p. 42. Cf. our ¶ 127.

376. NSF: *Scientific R&D of Nonprofit Organizations*, Expenditures & Manpower, 1957, 58 pp. p. 37. We took 18% from Table 25.

377. Battelle Mem. Inst. for NSF: *Research by Cooperative Organizations*, a Survey of Sci. Research by Trade Asns., Professional and Tech. Socs., and Other Cooperative Groups, 1953, 47 pp. Table 7, reduced by 6.6% to eliminate soc. sci., per table 3, and then by 12% according to the proportion of inventive sci. to non-inventive nonagri. sci. indicated by the 2d table on p. 24. Performance figures, with their wider basis, were from table 6, only "In House" from own funds.

378. Green, Jn. C. & Judkins, J.: *Tech. Research Activities of Cooperative Asns.*, Study No. 21 of the present ser., 1959, 59 pp.

379. N 377, table 7, which gives $11.5 m. from the Trade Asns. and $1.6 m. from other cooperative groups (p. 5). These are reduced by 3.5% to eliminate soc. sci., per table 3. Performance as in N 377.

380. *Revs. of Data*, N 40, p. 6; taking 52%.

381. Using NSF: *Science and Engg. in Amer. Industry*, Rept. on a 1956 Survey, 117 pp., p. 32 and table A–33.

382. Inventions Pay, in *Bus. Week*, Jan. 19, 1952, pp. 123–8. Cf. also J. F. Creed, R. B. Bangs and J. P. Driscoll: Fed. Taxation of the Inventor; *PTCJRE* 2:505–19, 1958.

McFadden J. A. & C. D. Tuska: *Accounting and Tax Aspects of Pats. & Research*, 1960, rev. by Rossman in *JPOS* 42:572–8.

383. N 376, table 4. Phys. scis., guessing 86% own funds, acc. to table 2. Add $6.1 m. for indep. research institutes, from p. 31 and table 17.

384. NSF: *Research and Development by Nonprofit Research Institutes and Commercial Laboratories, 1953*, prepared by Maxwell Research Center, Syracuse Univ., 1956, 81 pp. The foundations' own contributions were est. from tables 1 and 3, and from table 5 that 87% of all was related to invention.

385. *Revs. of Data on R&D*, No. 22, August 1960, table 3, reduced to 87% as above.

386. *Ibid.*, Table 4.

387. *Ibid.*, Table 3, for all R&D. One may compare also NSF: *Scientific Research Expenditures by the Larger Private Foundations, 1956*.

388. NSF *Revs. of Data on R&D*, No. 35, 1962.

389. From the source of our N 384, its table 26, it was est. that 95% of the commercial laboratories' work was related to invention. This percentage was applied to table 11, and for 1956 data, was applied to table B-2 of the *op. cit.* in N 381.

390. NSF *Revs. of Data on R&D*, No. 33, April 1962, table 1b, gives $2,240 m. as the sum put up by industry for conduct of research in 1953–4. For capital expenditures we use *Sci. & Engg.*, N 381, p. 32 and table A-33, indicating a building supplement of 32.5% in 1955–6. We assume the same percentage for building in 1954. From NSF's earlier rept., N 85, table A-14, it appeared that about 97% of the R&D was anent invention, so our figures are reduced to this percentage. Trade assns. are not included in our data, comrl. laboratories are.

392. *Sci. & Engg.*, N 85, p. 36.

393. Jewkes, J., Sawers, D., & Stillerman, R.: *The Sources of Invention*, 1958, 428 pp. Reviewed by Gilfillan in *Current Econ. Comment* 21:58–60. The many case histories of invention, by Stillerman, can be useful.

394. Arthur D. Little, Inc.: *The Military's Use of Resources and Technical Innovation*, Rept. to National Inventors Council and the Army, Navy and Air Force, Oct. 6, 1959, 57 pp. mim., p. 26. Cf. also Van Deusen, N 204 on the Inst.; and Schon N 669. A far more encouraging view of inventing for the military, though still with demonstration of obstructions, was obtained by questioning successful inventors, such as would probably usually fall in our category of the Organized. J. N. Mosel, assisted by B. S. Sanders & I. H. Siegel: Incentives and Deterrents to Inventing for National Defense; *PTCJRE* 1:185–215. In the same issue its Director J. C. Green describes the NIC, as also in How Does the Govt. Treat the Indep. Inventor?, *Product Engg.* 31:55, Aug. 15, 1960, claiming an adoption rate of about 1/1000.

395. Van Deusen, N 204, p. 132.

U.S. News & World Rept.: A Vanishing American, the small . . . inventor. Nov. 23, 1956, p. 113–6.

396. Sanders, B. S., & Rossman & Harris: Patent Acquisition by Corporations; *PTCJRE* 3:217–61, 1959; table 7.

397. Ame. Pat. Law Assn.: *How the Stanley Bill Imperils the Inventor*, 1922, at end; vs. McFarlane and Sen. bill.

398. Van Deusen, N 204, pp. 132, 3.

399. Chase, Stuart: Calling All Inventors; condensed in *Reader's Digest*, Jan. 1941, pp. 15–18.

400. Study No. 3 (N 138), table 6 provides the yearly count of patents issued to American corporations. We divide this for the latest year, 1955, by the number of patents to Americans in that year, 26,413, to get 61%. For later data we modify accordingly the data in *Hist. Stat. of the U.S.*, Rev. Ed. 1960, p. 599, and from Sanders (N 396), table 7 which provides data on patents assigned to companies later than on issue. We assume the same ratio (4.9%) of subsequent to initial assignment. Of these 58% were known from the Patent Office files, and 42% from inventor and other sources, since assignments are often not officially recorded, even sometimes assignments by contract before issue. Later assignments are especially to small companies.

401. Sanders, N 396, p. 255.

402. N 396, p. 218–8.

403. Sanders, B. S., & Rossman & Harris: The Growing Importance of Chemical in Comparison with Mechanical Patents, *PTCJRE* 4:84–91, 1960, p. 90.

404. Sanders, N 396, pp. 218, 237; and N 132, tables II and IV.

405. N 324, table IV.

406. The struggle of the successful independent inventor is told by the eminent and tragic Rud. Diesel, in A. Flettner: *Story of the Rotor*, p. 82.

407. MacKinnon, D. W.: Intellect & Motive in Scientific Inventors: Implications for supply. In *Rate & Dir.*, N 46, p. 367–78, followed by useful comments of T. S. Kuhn, 379–84. Cf. also MacKinnon, N 579.

408. Calculated from table 1 of N 132, and table D of mimeographed material of June 1957. The true ages would be somewhat older, due to deaths having removed more of the older, especially from 1938 patents.

409. Sanders, B. S.: Pat. Utilization Study. *PTCJRH*, 1st Conf., pp. 67–75 and 150–5; tables used.

410. Study No. 2, N 138. Cf. also Sanders, N 396, table 6. We used from Study 3, the 1955 data from table 6, as the latest available, reporting inventions worked on around 1951.

411. Study No. 22, N 432, pp. 19–34.

U.S. Govt. Pats. Bd.: *A Proposed Govt. Incentives, Awards & Rewards Program*, with respect to Govt. employees. 27 pp., 1952.

U.S. Senate Judiciary Com'ee: *Inventive Contributions Awards*, Rept. 1432, July 26, 1955.

Public Law 85–568, sec. 306, of 1958, Aeron. and Space Act.

Inventors' Awards, Hearing before Sen. Subcom'ee on Pats. on S. 2157 and H.R. 2383, June 7, 1956; 83 pp.

Inventive Contrib. Awards, Rept. of Com'ee on Judiciary, to accompany H.R. 101, Feb 21, 1957; 19 pp.

412. Since the 20 Nobel prizes in Physics and Chemistry to Americans have averaged one man and $25,713 per year in the previous 21 years, this figure was used instead of the larger 1956 grants, for statistical regularity. Our data, probably incomplete, are the U.S. recipients in an average year, from Herbert Brook, ed.: *Blue Book of Awards*, 1956. A few U.S. Government honors are included, but none of its cash awards or promotions. Ten cash awards of unstated amount were assumed to average half the stated.

413. From U.S. Civil Service Comn.: *Ann. Rept.* for 1959. These figures are also included in our Suggestion System statistics. (¶ 94)

414. From correspondence in December 1960 with Atomic Energy Comn., which named 2 awards in 1953–5, and with Nat. Aeron. and Space Adm., which in 2 years from the start of the awards act had recommended one cash award but as yet secured none.

415. Corry, C. C.: *Compulsory Licensing of Patents*, a legislative history. Study No. 12 of the present series, 1958; 70 pp. with bib.

Allen, Jul. W.: *Econ. Aspects of Patents & the American Patent System, a Bib.* Study No. 14 of the present ser., 1958; 54 pp. Pp. 26–37 cover Patents & Anti-trust Problems, incl. patent pooling, pp. 34–6, and Compulsory License.

Compulsory Pat. Licensing under Antitrust Judgments; staff rept. of the Senate Judiciary Com'ee's subcom'ee on Patents, etc., pursuant to S. Res. 240, 1960, 78 pp.

Addl. references on C.L. are in N 450.

416. Sanders, N 165, pp. 489–93.

418. Attitudes of Assignees N 137, table 21 and p. 489. Of assignees addressed, ½ or 600 responded. Other reasons given included Royalties 19%, Licensee request, 6.5%, on Government contract 5%, etc.

420. Nonpatentable & Noncopyrightable Trade Values; Private rights and the public interest; *Columbia Law Rev.* 59:902–37, 1959.

421. Legislating about Know-How; *Economist* 185:803, 1957. *Chem. & Eng. N.*, Sept. 8, 1958.

422. Bergier, J.: New Trends in the Sociology of Invention: Know-how vs. Patent; *Impact* 4:167–79, 1953; by a French engineer.

423. Pat. Tr.mk & Copr. Foundn.: *Digest*, No. 2, February 1961.

424. *Pat. & Technical Info. Agreements*, Study No. 24 of the present series, 1960, 79 pp.

425. Sanders: Attitudes, N 137, pp. 463–80, esp. tables 1, 5 and p. 472.

426. Study No. 3, N 138, p. 8.

427. Stigler, G. J.: *Five Lectures on Econ. Problems*, 1949, table II, using Manufacturing, Mining, Transportation and Communications as the inventive industries, and dropping Agriculture, Fisheries, Forestry, Contract Construction, Trade, Finance and Services as noninventive. Automobile manufacture, a borderline case was assigned to Monopoly. Table I supplies product value data for 126 industries, classified economically as in table II. On p. 50 Stigler obtains rather similar results from all industries, competition producing 70% of the national income and using more than 80% of the labor. All data are of 1939.

428. Performance from the fourth quantifying line under sec. 9, plus the percentage rating for the estimates for secs. 10 and 11 of col. 5, table 7.

429. Table 7, col. 3, lines 9b and 15, and col. 5 line 10, all added and reduced to 80% per ¶ 429. Add col. 5 line 11. Total $1891.4 m.

430. In 1953–4 the Govt. (N 369) and indus. (N 390) are set down as spending respectively $220 m. (97% of 227) and $729 m. (32.5% of 2.240) for additions to plant. Adding the total funds and the two building funds we get a grand total of $5,455 m., of which $949 m. was for capital additions, or 17.4%.

431. The Panel, established about a year before, was composed in February 1963 of the President's Spec. Asst. for Sci. & Tec., the Chmn. of the Council of Ec. Advisors, and the Sec. of Commerce, with Michael Michaelis as Ex. Sec.

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438. Study No. 11, N 65, Chaps. 8 and 9.

439. *Revs. of Data*, N 40, p. 7.

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446. Some expressed by the foundations themselves are given in N 384, p. 18.

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