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

[603] 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.

[604] 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.

[605] 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.

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 [59]; 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 non-secretarian 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?[608] Yet only during about the last dozen years,

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[608] 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

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.

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[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.*, ftN55, 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 Instits. 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.

Siegel, I. H.: Pat. Info. in Ann. Repts; Potential contributor to corporate image; *PTCJRE* 4:208–211, 1960.

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; *Fontune* 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.

Borkin, J.: The Pat. Infringement Suit: Ordeal by Trial, 17 *Chicago Law Rev.* 634.

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 relative 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 ⅓, 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 ¶ 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 ncludes 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 Inv.*, 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. Am. Pat. Law Asn.: *How the Stanley Bill Imperils. . . . 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 Dig.*, 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.

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 1 and 9.

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 mim. 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; *PTCJRE* 1: Conf. No., 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 & Antitrust 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.
432. Jibrin, Barbara, & Corry, C. S.: *Govt. Assistance to Inv. & Research*: a Legislative History, Study No. 22 of the pres. ser., 1960, 199 pp.
433. *Rept.* for 1962.
434. *Wall St. Jol.* June 6, 1961, p. 1.
435. *Rapport d'Activité* for 1959–60, pp. 8, 30.
436. Vernon, Study 5, our N *203.*
Ladd, N 437.
Westerman, G. F.: A Common Pat. in the Common Mkt., *JPOS* 44:444–61, 1962.
An Internat. Patent Search Bureau; *Intl. Bull. of Indus. Property* 1: 221–3, 1948.
Meller W. M.: Toward a Multinational Pat. Sys.; *JPOS* 44:227–73, 1962.
PTCJRE, Conference No., 1962, various papers.
Laude, K. E.: A Step Toward a European Patent: the Common Market Patent; *JPOS* 42:698–701, 1960.
Robbins, L. J.: The Proposed New Eur. Pat.: *PTCJRE* 5:217–32, 1961.
Senate Subcom'ee on Pats. etc.: Rept. 97, our N 277, pp. 24,5.
Spencer, R.: A Eur. Pat.; *Am. Bar Asn. J* 45:1157–9, 1959.
Stringham, N 453.
The Proposed European Patent Law. A Summary Analysis. Also: Draft Convention Relating to a European Patent Law; *JPOS* 45:No. 3, 1963.
437. Ladd, Comr. D. L.: The Pat. Plans of the Common Market Countries; *JPOS* 44:583–92, 1962, pp. 591,2.
438. Study No. 11, N 65, Chaps. 8 and 9.
439. *Revs. of Data.* N 40, p. 7.
441. By Ralph Rabbards to Queen Elizabeth I. Cf. H. Dircks: *Inventors and Inventions*, pp, 196–202.
442. Palmer, A. M., Study No. 6 of the pres. ser. N 160, pp. 20–40.
Palmer: *Nonprofit Research & Pat. Mgmt. Org.* 1955, 150 pp.
443. Palmer, A. M.: *Univ. Pat. Pools & Practices*, 1952, 229 pp., p. 99 etc., quoted his Study No. 6, our N 160, p. 47. etc.
444. *Wall St. Jol.*, Feb. 7, 1961.
445. Barker, J. W.: *Research Cp. (1912–52)*, 24 pp. in Newcomen Soc., Amer. Branch: *Addresses* 13: No. 1.
446. Some expressed by the foundations themselves are given in N 384, p. 18.
447. *JPOS* 16: 589–90 and 17:84–6, 1935.
448. Glaser, B. G.: *Some Functions of Median Recognition for Scientists in a Research Organization*, Columbia U. dissertation in Sociol., 1961 (?)
449. Melman, Study 11, N 65, p. 61.
Frost, N221, p. 14, note 44, is critical.
NAM, N 467, p. 76.
Graham, Jn. P.: *Awards to Inventors*, Lon., 1946.
Polanyi, N 223.
Davis, A. S.: The Pat. Brouhaha; *Intl. Sci. & Tec.*, May 1962, pp. 60–5.
Draper, C. S.: The Pat. Sys. from a Scientist's Point of View; *PTCJRE* v. 5, Conf. No., 70–6, 1961.
450. In addition to the Senate Subcom'ee's 3 repts. listed in N 415, cf.: Abramson, Study 26, ftN *197*, chap. 4, Gen. Comp. Licensing, with a second rept. promised on C.L.
Frost, N 221, pp. 28–33, C.L.—Myth vs. Fact.
Cantor, B. J.: Evolution toward Comp. Licensing? *JPOS* 35:372–6, 1953.
Van Cise, N 21.
451. Bachmann N 127, pp. 158–60.
453. Neumeyer, F.: *Comp. Licensing of Pats. under some NonAmer. Systems*, Study No. 19 of the present series, 1959, 51 pp.
Meinhardt, N 318.

Vaughan, F. L.: Pat. Policy; *Am. Ec. Rev., Proc.* 38:215–34, 1948.
Stringham E: *Pats. & Gebrauchsmuster in Intl. Law,* 1935.
Reik, N 216.
Federico, P. J.: Comp. Licensing in Other Countries; *Law & Contemp. Problems* 13:295–309, 1948, with stat. of use.
454. Comp. Pat. Licensing and its Effects; *PTC Foundn. Digest,* No. 4, Nov. 1961. See also ¶ 469.
455. Federico, N 453, pp. 300,1.
456. Urge Tougher Pat. Rules; *Bus. Week,* May 14, 1960, p. 122; and Subcom'ee on Pats., N 450.
457. In conversation and correspondence. Cf. the *Electronics* article of N 223.
458. Harrison, Gladys: *An Analytical Hist. of the Pat. Policy of the Dept. of HEW,* Study 27 of the pres. ser., 1960, pp. 7–11, esp. 10.
459. In their 3d Rept., N 472.
460. Study No. 1, N 320, pp. 24–7.
461. Bachmann, N 127, p. 138, 142, etc. & and tables 11–13. Based on pats. issued to 38 companies hit by CL decisions, in 1947–52, comparing their percentage of the national patenting (9.46%) during 1939–55, with the same in 1954–6, further refined (stat. by company). See also chap. X: What is a Reasonable Royalty? and p. 155.
462. 4% in England, 6% in Germany, in 1937–40. Federico N 453.
463. Burlingame, R.: *March of the Iron Men,* a soc. hist. of union through inv. 1938, 500 pp., p. 371.
464. Howard, Frank A., former Pres. of Std. Oil Devmt. Co., in a dinner address to PTC Foundn., June 13, 1957.
465. Stedman, J. C.: Trade Secrets; *Ohio State Law J.* 23:4–34. Nash, J. B.: The Concept of "Property" in Know-how as a Growing Area of Indus. Property: Its Sale and Licensing; *PTCJRE* 6: 289–98, 1962.
466. Neumeyer, Study 19, N 453, p. 38.
467. Nat. Assn. of Mfrs.: *Indus. Believes,* 1962, p. 77.
468. Gilfillan: *Sociology of Inv.,* N 49, pp. 82–94, 89 quoted.
469. Brown J. B.: The Situation Confronting Our Pat. Sys.; *JPOS* 21:159–94, 1939; p. 163, followed by much good discussion of pat. reforms. P. 184.
471. Fleming, H. M., in *Pub. Int.,* N 134, p. 51,2.
472. A. A. Potter, engg. coll. pres., was chosen Dir.; C. F. Kettering was chmn.
U.S. Nat. Pat. Planning Comm.: *The Amer. Pat. System,* 1943; Message from the Pres. transmitting it to Cong. Also their *3d Rept. on the Am. Pat. Sys.,* 27 pp., in House Docs., 79th Cong., 1st sess., Sept. 6, 1945.
Federico, P. J.: Current Activities Toward Revision of Pat. Law; *Chem. & Engg. N.* 25:840–3, 1947, summarizes the various repts.
473. Edwards: *A Statutory Std. of Inv.,* N 518.
Daniels & Edwards: *Recordation of Pat. Agreemens,* a Legislative Hist., 1958, Study No. 9 of the pres. ser.
Corry: *CL of Pats.,* N 415.
Allen: *Econ. Aspects,* N 415.
Conway.: *A Single Court of Pat. Appeals,* N 503.
———: *Expediting Pat. Office Procedure,* N 487.
474. Folk, G. E.: *A Rev. of Proposals for Revision of the U.S. Pat. Sys., 1946,* 46 pp., summarizes the recommendations of each of these bodies, and supplies those of the Nat. Assn. of Mfrs., who published the brochure and whose Pat. Advisor Folk was.
475. U.S. Sci. Adv. Bd.; N 270. The distinguished com'ee were V. Bush, chmn., W. H. Carrier, D. M. Compton, F. B. Jewett, and H. A. Poillon; none of them pat. professionals.
476. U.S. TNEC: *Hearings. Part 1, Econ. Prolog.,* Dec. 1938, pp. 1–252, with much econ. data. *Part 2,* N 299; *Part 3, Pats., Proposals for Changes in Law and Practice,* 1939, pp. 835–1148, with stat. *Part 30, Technology & Concentration of Econ. Power,* N 38.
477. U.S. Dept. of Commerce: *Pat Survey Com'ee,* 1945, 10 pp. Beside the Chmn. the members were V. Bush, C. F. Ketterring, and Atty. Gen. T. C. Clark, succeeded by Morris L. Cooke. They appointed W. H. Kenyon, Jr., pat. atty., as counsel.
478. V. Abramson's Study No. 26 (ftN *197*).
479. Ladd, D. L.: The Pat. Office—an Old Line Agency in a Modern World; *JPOS* 43: 515–25, 1961. The Comr. of Pats. recommends this and suggests a number of other good and drastic possible changes in the pat. sys.
480. Study 17, N 231, pp. 39,40.

481. Bailey, M. F.: A Standard of Patentability; *JPOS* 41: 192ff and 231ff., 1950.
482. Brit. Sci. Guild: *Rept. on the Reform of the Brit. Pat. Sys.*, 1928, 48 pp.
484. Federico, P. J.: *Opposition and Revocation Proceedings in Pat. Cases*, Study 4 of the pres. ser., 19 pp. 1957, closing with a preliminary draft bill.
485. Sen. Pats. Subcom'ee's Rept. 1202 of Mar. 16, 1960: *Pats., Trademarks, & Copyrights*, 25 pp., pp. 24,5.
486. Senate *Rept.*, N 277, pp. 24–8.
487. *Expediting Pat. Office Procedure, a Legislative Hist.*, Study 23 of the pres. ser., by M. M. Conway, 1960, 105 pp., with bib. pp. 95–105, beside bill list.
489. *Bus. Wk.* Jan. 26, 1957, pp. 149–52: Pat Law Reforms Take Shape.
490. Bush, Study No. 1, N 320, pp. 20,1.
491. Zangwill, B. L.: Suggested Outline for a New Pat. Sys.; *JPOS* 39: 689–93, 1957.
492. Study No. 2, N 221, Frost's note 184, citing a proposal by the Com'ee for the Study of Amendment of the Procedure for Granting Pats., 1956, mentioning the Dutch system.
493. Reported by Comr. Ladd, N 479, p. 518.
494. White, C. M.: Why a 17-year Patent? *JPOS* 38: 839–60, 1956.
495. SAB, 2d rept., N 270.
496. N 215, p. 668.
497. Davis, N 209, p. 806.
499. Sanders, N 403, his p. 90, initially assigned pats of 1952.
500. NPPC, N 472, pp. 15,16.
501. N 215, p. 659.
502. N 320, pp. 22,23.
503. Whinery, L. H.: *The Role of the Court Expert in Pat. Litig.*; Study No. 8 of the pres. ser., 1958, 96 pp.
Conway, Mgt.: *A Single Court of Pat. Appeals*, a Legislative Hist., Study No. 20 of the pres. ser., 1958.
Sen. Subcom'ee: *Rev.*, N 312, p. 7.
504. Davis, N 449.
505. TNEC: *Hearings, Pt. 31–A, Supplemental Data Submitted to the TNEC*, 1941, p. 18055.
506. Folk, N 474, p. 36,7.
507. Wilson, N 201, p. 180.
508. Rice, N 301, p. 180ff. or p. 17ff.
509. *Nat. Petrol.* N 37: 14, Jan. 17, 1945.
510. Ladd, N 271, p. 364ff.
511. Hill, T. A.: Needed Reforms in the Pat. Sys.; *Machinery* 30: 681–4, 1924.
512. McBride, R. S.: Proposed Pat. Office Reforms; *Electronics* 4: 116–7, April 1932.
513. Annual Rept. of Comr. of Pats. for 1960, pub. in *JPOS* 43: 389–417.
Newman, S. M.: Classified Pat. Search Files, a Proposed Base for Tech. Info. Centers; *JPOS* 43: 418–34.
Crews, M. A.: The Three Pat. Incentives; *JPOS* 43: 554–64, 1961. This former Asst. Comr. of Pats. proposes various improved info. services from pats.; p. 561 etc.
A Feasibility Study for a Regional Scientific Info. Center announced as near completion; in U.S. NSF: *Current Projects on Ec. & Soc. Implications of Sci. & Tec.*, 1961, p. 94. On pp. 103,4 see Appendix B: Other Related Complications of Research Projects.
514. Sen. Rept. of Apr. 3, 1961, N 2, esp. pp. 6–8.
Watson, D. S., Bright, H. F. & Burns, A. E.: Fed. Pat. Policies in Contracts for Research and Devmt.; *PTCJRE* vol. 4, whole of No. 4, 1960.
515. N 514 and *PTCF Digest*, No. 5, June 1962.
516. Grossfield, K.: Invs. as Bus.; *Econ. Jol.* 72:12–26, 1962; re the Nat. Research Devmt. Cp. in Britain.
517. Stedman, N 215, pp. 664,5.
Abramson, Study 26, ftN *197*, esp. p. 13.
518. Edwards, V. L.: *Efforts to Establish a Statutory Standard of Invention*; Study No. 7 of the pres. ser., 1958, 29 pp., p. 7 cited.
519. *Research by Coop. Orgs.*, N 377, tables 6 and 4.
520. Study 21, N 378, pp. 4,5.
521. Arnold, Philip M.: Why Not Try Cooperative Research?; *Harv. Bus. Rev.* 32: 115–22, 1954. Asks expansion under present laws.
522. N 377, table 6.

523. G. B.: *Official Handbook*, 1960.
524. First proposed by the present writer, in his *Sociology of Inv.*, N 49, pp. 125,6, and better in his A New System for Encouraging Inv., *JPOS* 17:966–70, 1935, and in his mim. brochure of 1938, *Pat. Pooling and its Betterment*, 29 pp. An anon. article in *Chem. Age* 31:546, 1923, proposed a somewhat similar plan, but much weaker.
526. Merrill, R. S.: Some Societywide Research and Devmt. Institutions; in *Rate & Dir.*, N 46, pp. 409–34–40, with comments by J. J. Spengler. Considers pure academic research in the natural sciences, medicine, and engg., and Govt. agric. research.
527. Green & Judkins, N 378, p. 23.
528. On the basis of 12 modern process inventions, counting from 2 yrs. before the first major firm's adoption of the inv., from data of E. Mansfield: Diffusion of Technol Change: NSF's *Revs. of Data on R&D*, Oct. 1961.
529. NSF: *Funds for Research & Devmt. in Indus., 1959*, table XIII.
531. Prelim. est. for 1960–1, from NSF: *Revs. of Data on R&D*, Apr. 1962, table 1b.
532. Stedman, N 215, p. 676.
533. *Elec. Technol & the Pub. Int.*, N 211, p. 126.
534. McBride, R. S.: Proposed Pat. Changes; *JPOS* 14:353–61, 1932, on Hearings of the House Com'ee.
535. Hillier, Jas.: The Untapped Promise of Electronic Medicine; summary in *Atlantic*, Apr. 1961, pp. 12,14.
536. Benton, Mildred, compiler: *Creativity in Research & Inv. in the Phys. Scis.*, a valuable annotated bib. of 1359 entries, 151 pp., pub. by U.S. Naval Research Lab., 1961.
537. Usher, A. P.: *A Hist. of Mech. Invs.*, rev. ed. 1954, 450 pp. An important work, including its extensive treatment of the Psy. of invention.
538. Harmon, L. R.: Social and Technologic Determinants of Creativity; in Taylor, ed., N 600, 1955, pp. 45–52; reviewed in Stein & Heinze, N 562.
540. Golovin, N. F.: The Creative Person in Sci. in Taylor ed., N 600, 1959, pp. 268–81, attempts the most elaborate explanation of this widely mentioned process.
541. Kettering, C. F.: How Can We Develop Inventors? in Von Fange, N 556, Appendix 1, pp. 223–34; p. 224.
543. Platt, W. & Baker, R. A.: Relations of the Scientific "Hunch" to Research; *Jol. of Chem. Educ.* 8:1969–2002, 1931; p. 1999 cited in ¶ 582, p. 1994ff. cited in ¶ 469, p. 1989 cited in ¶ 470.5, p. 1979 cited in ftN *553*.
Rossman, N 562, chap. 6, The Mental Processes of the Inventor.
544. Bell, Wm. B.: The Executive & the Technologist—a proper understanding between them; *Indus. & Engg. Chem.*, News ed., 18:185–90, Mar. 10, 1940.
545. Cf. the jol. *MT*, Mechanical Translation, pub. by MIT.
546. Arnold, Jn. F.: Creativity in Engg. In Smith, Paul, ed.: *Creativity*, an Exam. of the Creative Process, 1959, pp. 33–46.
547. Osborn, Alex F.: *Applied Imagination*, Principles and Procedures of Creative Thinking, 1953, 317 pp.
———: *Is Educ. Becoming More Creative?* Pamphlet pub. by Creative Educ. Foundn., U. of Buf.
Hodgson, D.: Brainstorming—valuable tool or passing fancy? A good description and strong support. *Indus. Marketing*, December 1957, 5 pp.
Whiting, C. S.: *Creative Thinking*, 1958, 168 pp.
The Benton bib., N 536, covers Brainstorming in items 631–63.
See also Hix & Purdy, N 617; Mason N 620; Pearson N 626.
548. Hunt, M. M.: The Course where Students Lose Earthly Shackles; *Life* 38:186ff., May 16, 1955, describes the courses of Prof. Jn. E. Arnold.
549. Brainstorming is sharply criticized by E. R. Hilgard, D. W. Taylor and others in Hilgard: Creativity & Problem-solving, in H. H. Anderson ed.: *Creativity and its Cultivation*, for Interdisciplinary Symposia on Creativity, 1959, 293 pp., pp. 162–80, esp. 170,1. It is warmly endorsed by its users, such as Osborn; and Harris, N 618, using it in AC Spark Plug Div., claims immediate benefit from class-produced ideas. Cf. also Harmon N 538; Stein & Heinze N 562, p. 407–9; Benton bib., N 536, Nos. 631–63; and N 547.
550. Brown, J. D.: A Climate for Discovery; by the dean of the Princeton faculty. In U.S. NSF: *Proc.*, N 600.
554. Easton, Wm. H.: Creative Thinking & How to Develop it; *Mech. Engg.* 68: 697–704, 1946.
555. Kettering, C. F.: Inv. & Educ.: *Vital Speeches* 17:346–8, 1951.

556. Von Fange, E. K.: *Professional Creativity.* 1959, 200 pp. By the Dir. of GE's training course, in which it serves as a textbook.

557. Guilford, J. P.: Traits of Creativity; in Anderson ed., N 549, pp. 142–61; p. 151.

558. Gordon, W. J. J.: Operational Approach to Creativity. *Bus. Rev.*, November 1956, pp. 41–51.

Heinz, W. C.: You Name It, They'll Invent It; *Colliers*, 135:76,7, Apr. 29, 1955.

559. Nicholson, Scott: Group Creative Thinking; *Management Rec.* 18:234–7 and 256, 1956.

560. Taton, R.: *Reason and Chance in Scientific Discovery*, tr. by A. J. Pomerans, 1957.

562. Rossman, Jos.: *Industrial Creativity: The Psychology of the Inventor*, 1931, 252 pp. New ed., w. updated bib., New Hyde Pk., N.Y., University Bks., 1964. A classic work, by a psychologist-chem. engr.-pat. atty. Chap. 7 Chance & Accident in Inv., for ¶ 594.

Armstrong, E. H.: Vagaries and Elusiveness of Inv.; *Elec. Engg.* 62:149–51, April 1943.

Stein, Morris I. & Heinze, S. J.: *Creativity & the Individual.* Summaries of Selected Literature in Psychology & Psychiatry. 1960. A valuable collection of summaries and excerpts of more than 300 articles, 428 pp. P. 76,7 for ¶ 594.

563. Claude, Georges: Ideas of an Inventor; *Tec. Engg. N.*, 10:7ff., reviewed in *Sci. Am.* 140:568,9; 1929.

565. Smith, Philip M.: Breeding Machine Brains, *Sci. Am.* 155:5ff. 1936.

567. Hadamard, J. S.: *An Essay on the Psy. of Inv. in the Math. Field*, 1945, 156 pp.

569. Gilfillan, N 147, esp. 161–75.

570. Roe, Anne: Early Differentiation of Interests; in Taylor ed. 1957, N 600, p. 98–108.

571. Welch, E. W.: Motivational Factors in Choice of Profession by Amer. Scientists. Stanford dis. *Dissertation Abstracts*, 120: 1233, 1959.

572. Sheldon, W. H.: *Varieties of Human Physique*, 1940, gives some of the evidence on intellectuality.

573. Roe, Anne: *The Making of a Scientist*, 1953, 244 pp., chap. 7. Based on elaborate psy. examinations of 64 eminent scientists.

574. Visher, S. S.: *Scientists Starred 1903–43 in Am. Men of Science*, a study of collegiate and doctoral training, birthplace, distribution, backgrounds, and developmental influences; 1947, p. 556 etc. Summary in Stein & Heinze, N 562.

576. West, S. S.: Sibling Configurations of Scientists: *Am. J. Sociol*, 66:268–74, 1960.

577. Roe, Anne, N 573.

Time, Feb. 9, 1962, pp. 48–50; 53,4.

Thistlethwaite, D. L.: The Coll. Environment as a Determinant of Research Potentiality; in Taylor ed., N 600, 1959, p. 219.

578. McPherson, Joe: Some Comments about the Relationship between Industrial Research Laboratory "Climate" and the Individual Scientist; in Taylor ed., N 600, 1959, pp. 94–103, citing Maslow on p. 94.

579. MacKinnon, D. W.: Fostering Creativity in Students of Engg. *Jol. of Engg. Educ.* 52: 129–42, 1961., with bib.

580. Indus. Research Inst.: *The Nature of Creative Thinking*, 1952,3; 73 pp.

Barron, F.: Needs for Order and for Disorder as Motives in Creative Activity; in Taylor ed., N 600, 1957, p. 119–28, esp. 123.

Cooley, W. D.: Attributes of Potential Scientists; *Harv. Educ. Rev.* 28: 1–18, 1958.

Guilford, J. P.: Com'ee Rept. on the Predictors of Creativity; in Taylor ed., N 600, 1959, pp. 298–308.

582. Cattell, R. B.: The Personality and Motivation of the Researcher from Measurements of Contemporaries and from Biography; in Taylor ed., N 600, 1959, pp. 77–93, esp. table 1.

583. Rossman, J.: Heredity & Inv.; *Jol. of Hered.* 21: 507–12. 1930, enlarged fr. his *Psy.*, N 562, chap. 12. Nearly 40% had relatives who were inventors. Cf. Hadamard, N 567.

584. Szent-Györgyi, A: Secret of the Creative Impulse; *N.Y. Times Mag.*, July 30, 1961, pp. 14, 34, 36.

585. Mellinger, Jn. J.: A Study of Creative and Inventive Talent. A then unpub. progress rept., quoted by Renck & Livingston, N 613, p. 3.

586. Roe, Anne: The Psychology of the Scientists; U.S. NSF: *Sci. Manpower, 1960*, pp. 48–52, p. 52 quoted.

587. Hutchison, E. D.: *How to Think Creatively,* 1949, 237 pp.

588. Bloom, S. S.: Studies of Creative vs. Noncreative Individuals (chemists and mathematicians); in Taylor ed., N 600, 1955, pp. 183–94.

589. Benton, N 536, item 1292.

590. Knapp, R. H.: Demographic Cultural & Personality Attributes of Scientists; in Taylor ed., N 600, 1955, p. 204–12, Cf. also his Personality Com'ee Rept., in *do.* p. 229–41.

Trow, M.: Some Implications of the Soc. Origins of Engrs.; in U.S. NSF: *Scientific Manpower, 1958,* pp. 67–74.

591. Stein, M. I.: Creativity and the Scientists; and A Transactional Approach to Creativity; rev'd in Stein & Heinze N 562, pp. 318–22.

592. Van Zelst, R. H. & Kerr, W. A.: Some Correlates of Tech. & Sci. Productivity. *Jol. of Abnormal Psy.* 46:470–5, 1951. Their highest correlation, .75, between publications and invs., corrected for personal age, with various traits and habits, in the faculty of a tech. university.

593. Harmon, L. R.: The H. S. Backgrounds of Sci. Doctorates; U.S. NSF: *Scientific Manpower, 1960,* pp. 14–28, tables 12, 14 and 1.

594. Meier, R. L.: The Origins of the Scientific Species; *Bull. of the Atomic Scientists* 7: 169–73, 1951.

595. Rossman, Jos.: A Study of the Childhood, Educ., and Age of 710 Inventors, drawn from his patentees of 1927–9 (N 562) and from *Who's Who in Engg.*; *JPOS* 17: 411–21, 1935. College grads. were 555. Cf. also his *Psy. of the Invr.*, N 562.

596. ———: Engineers as Inventors; *JPOS* 13: 376–83, 1931, p. 379.

597. Carr, L. J.: A Study of 137 Typical Inventors; *Pubs.* of Amer. Social. Soc. 23: 204–6, 1929.

600. *Multiple author* books, and works not cited from our particular passages on the psychology of invention and inventors:

- *Am. Behavioral Scientist,* December 1961, various articles and annotated bib. of 346 titles related to soc. inv., incl. the psy. of inv.
- Amer. Mgmt. Assn.: *Creativity: Key to Continuing Progress. Bull.* No. 4, 1960, 27 pp. Cf. N 657, 658.
- Arnold, J. E. *et al*: *Creative Engg. Seminar,* at Stanford U., 1959.
- Barber, B. & Hirsch, W., eds.: *The Sociology of Science,* a Reader, and Symposium, 1962, 662 pp.
- Benton: *Creativity in Research & Inv.* See N 536.
- Boirel, René: *l'Invention,* 1955, 113 pp.
- *Contemp. Approaches to Creative Thinking.* Symposium, 223 pp. 1962. *Dissertation Abstracts*
- Flory, C. D.: Developing and using our Creative Abilities; *Chem. Engg. Progress* 49:676–8, Dec. 1953.
- Haefele, J. W.: *Creativity & Innovation.* 1962, 306 pp.
- Indus. Research Inst.: *Bib. on Creativity,* 1955. Lists 1919 items, by author; comprehensive, not selective.
- Middendorf, W. H., & G. T. Brown: Orderly Creative Inventing; *Elec. Engg.* 76: 866–9. 1957. By inventors.
- Parnes, S. J., & H. F. Harding, eds.: *A Source Book for Creative Thinking.* ca. 1960, 393 pp.
- Pólya, G.: *How to Solve it,* a new aspect of math. method. 1945.
- Porterfield, A. L.: *Creative Factors in Sci. Research,* 1941.
- *Scientific American.* The issue of September 1958 is devoted to creative thought, in phys. sci. and inv. *See esp.* F. J. Dyson: Innovation in Phys.; J. Bronowski: The Creative Process; J. R. Pierce: Innovation in Technol.
- Smith, Paul, ed.: *Creativity,* an Examination of the Creative Process. A symposium, 1959, 210 pp. See esp. Arnold, N 546, Carter, Pleuthner and Flanagan.
- Sprecher, T. B.: An Investigation of Criteria for Creativity in Engineers. Dis., U. of Md., 1957, 188 pp. Cf. *Dis. Abstracts,* 18:1101.
- Stein & Heinze: *Creativity and the indiv.* See N 562.
- Taylor, C. W.: *The State of Present Knowledge in Creativity,* 1962 (?)
- Taylor, C. W., Smith, W. R., & Ghiselin, B.: Analysis of Multiple Criteria of Creativity & Productivity of Scientists, in Taylor, ed., 1959, below, pp. 5–28.
- Taylor, Calvin W., ed.: *Research Conf. on the Identification of Scientific Talent.* Proc. of four successive valuable conferences in Utah; 1955, 268 pp.; 1957, 255 pp: 1959, 334 pp. The rept. of the 4th Conf. is entitled *Identification and Devmt. of Creative Scientific Talent.*
- Thurstone, L. L.: The Sci. Study of Inventive Talent; U. of Chgo. Psychometric Lab., *Lab. Repts.* No. 81, 1952.

U.S. NSF. *Proceedings of a Conference on Acad. & Indus. Basic Research*, at Princeton U., 1960, 87 pp.
Wortley, Edw.: *How to Get Original Ideas;* a course of 36 lessons in developing originality. 1941, 234 pp.

602. Getzels, J. W. & P. W. Jackson: The Highly Intelligent and the Highly Creative Adolescent; in Taylor ed., N 600, 1959, pp. 46–57. And/or the authors' Occupational Choice and Cognitive Functioning: Career Aspirations of Highly Intelligent etc.; in *J of Abnormal & Soc. Psy.* 61:119–23, 1960; or their *Creativity & Intelligence*, 1962. It was a very superior school, with mean IQ 132, and 499 pupils.

604. Torrance, E. P.: *Guilding Creative Talent.* 1962 (?)

606. Smith, Burke: The Engineer as an Inventor; a stat. study based on 959 out of 5,384 in *Who's Who in Engg.* who mentioned inventing. *Mech. Engg.* 56: 263–5, 1934.

607. Famous Educators' Plan that will Advance Students According to Ability; *Life* 44: 120–1 etc., Apr. 14, 1958.

609. Kubie, L. S.: Fostering of Creative Scientific Productivity; *Daedalus* 91: 294–309, 1962.

610. Guilford, J. P.: Can Creativity Be Developed? *Educ. Dig.* 24:49–51, December 1958.

613. Renck, R. & Mrs. C. W. Livingston: *Developing Creative-Inventive Ability;* U. of Chic. Indus. Relations Cen., A. G. Bush Library, Occasional Papers, No. 23, 1961, 10 pp.

614. Stevenson, A. R., & Ryan, J. E.: Encouraging Creative Ability; *Mech. Engg.* 62: 673,4, 1940.
Taylor, Mack: Road Test for Brains; *Nation's Bus.*, October 1949, pp. 33, 76,7.

615. GE: *GE's Creative Engg. Program*, n.d., 11 pages.
GE: *Advanced Courses in Engg.*, 12 pages.
Allen, M. S.: Working Procedures of Creative Scientists; in Taylor ed., N 600, 1957, pp. 192–200.
Nicholson, N 559.

616. Conrad, A. G.: Is Invention Stimulated by Elec. Engg. Training?; *Jol. of Engg. Ed.* 27: 692–8, 1937. This professor's answer is a strong negative. Pp. 695,6 for ¶ 616 p. 697 for ¶ 626.
Gehman, R.: Here's How To Train Your Own Inventors. *Nation's Bus.*: 43: 28–30 & 100, February 1955. History of the GE course.
Also N 193.

617. Hix, C. F. & D. L. Purdy: Creativity can be developed. *GE Rev.* 58: 20–3, May 1955. Describes GE's Creative Engg. Seminar.
Purdy, D. L.: Creative Engg., a Concept; *Personnel Adm.* 20: 7–13, May 1957. Describes GE's program.
Hays, Carl V., & J. R. M. Alger: Creative Synthesis in Design. Prentice-Hall Inc., 1964. Hays was a GE teacher of inventing.

618. Harris, R. H.: A Creativity Training Program. *Mich. Bus. Rev.* 8:26–32, May 1956. See also Whiting, N 547, pp. 144–6, quoted.

619. Simberg, A. L. & T. E. Shannon: The Effect of AC Creativity Training on the AC Suggestion Program; *AC Personnel Research Rept.* No. 27, Mar. 27, 1959, 8 pages.

620. Mason, Joe: *Suggestions for Brainstorming*—tec. & research problems, 8 pages. Creative Educ. Fndn., pub. Describes methods at 3M's.

621. Wilson, R. Q.: *A Creative Approach to Research and Teaching*, 1962, 13 pages, pub. by the author's Battelle Mem. Inst., Cleveland.

624. Prof. J. T. Tykociner's 1962 course in "Zetetics", i.e. investigation.

625. Teare, B. R. & Ver Planck: Engg. Analysis Courses at Carnegie. 3 pages n.d.
Ver Planck, D. W.: Engg. Analysis as Training in Ingenuity; *Jol. of Engg. Educ.* 45: 523–5, 1955.

626. Pearson, D. S.: *Creativeness for Engineers*, 1957, 150 pages.

628. Rossman, J.: Do Engrs. Invent, and Why Do They Abhor the Label Inventor? *Technol. Rev.*, v. 34, December 1931.

629. Kettering, C. F.: Inv. & Educ.; *Vital Speeches* 17: 346–8, 1951.

630. *Forbes' Mag.*, Dec. 15, 1951: The Inventor, Vanishing American; p. 14 quoted. Abstr. in *Mgmt. Rev.* 41: 296,7, May 1952.

631. Simpson, W. M.: Developing Creative Ability; *Mach. Des.* 23: 225ff., September 1951, p. 228.

632. Kuhn, T. S.: The Essential Tension: Tradition and Innovation in Scientific Research; in Taylor, ed., N 600, 1959, pp. 162–77, esp. 165, 170.

634. U.S. NSF: *Scientific Manpower, 1956*, signif. devmt., views and stat.

636. N 331, p. 141, etc.

638. Engrs. Jt. Council, Com'ee on the 1946 Survey: *The Engg. Profession in Transition,* prep'd by A. Fraser, 1947; using tables 2.3*e*, 1.8*k* and p. 30*f*.
Faltermeyer, E. K.: Engg. Enigma: Govt., Professions Seek Reasons for Drop in Student Enrollments; *Wall St. Jol.* Aug. 27, 1962, pp. 1, 15.
639. Feiss, J. W.: New and Changing Activities of Scientists and the Implications; in U.S. NSF: *Scientific Manpower,* p. 18 of pp. 12–22, 1957.
641. Wechsler, D.: *The Measurement of Adult Intelligence*; 1944, 3d ed., pp. 55–7, 30, 93,4,7; cited by Schmookler, N 643.
642. Lehman, H. C.: Age and Achievement: in *Mem. of Am. Philos. Soc.,* v. 33, 1953, used by Schmookler, *infra.* Cf. Benton bib., N 536, items 597–630.
643. Schmookler, J.: The Age of Inventors; *JPOS* 38:223–32, 1956. Table II used, in which Lehman's data are adjusted for pop. of age groups; p. 232 quoted.
645. Manniche, E., & Falk, G., cited in *Sci. Am.,* January 1958, p. 46.
646. Spooner, Thos.: Age of Invention; *Tecnol. Rev.* 49:37–41, 52,4, 1946.
647. Lehman, H. C.: Age of Starting To Contribute vs. Total Creative Output; *J. Apl. Psy.* 30: 460–80, 1946, rev'd in Benton bib. (N 536), item 611.
648. Stevens, R.: Viewpoint of the Research Administrator; *Sci. Mo.,* 72: 364–7, 1951. On age.
649. On labs. in general, *see* Bush & Hattery: *Teamwork,* N 67, and by the same editors, *Scientific Research, Its Adm. & Org.,* 1950, 198 pp.
650. Spangler, S. B.: The Role of Creativity in Indus. Today; in Am. Mgmt. Assn.: *Creativity,* N 600, pp. 1–8.
651. Secrist, H. A.: Motivating the Indus. Research Scientist; *Research Mgmt.* 3:57–64, 1960.
652. Bush, V.: *Sci. and Business,* address at Rutgers U. Bus. Conf., 1958, pub. by Merck & Co., 12 pp.
653. Deutsch & Shea, Inc.: *A New Look at Engr. Attitudes,* 1961, 60 pp., p. 17; pub. by *Indus. Relations News.*
654. Marcson, S.: The Scientist as an Indus. Research Employee. Pp. 43–4, in U.S. NSF: *Proc.,* N 600.
655. Amer. Mgmt. Assn.: *Optimum Use of Engg. Talent,* Meeting the need for tec. personnel, 1961, 416 pp., p. 85,6.
656. Harbison, F. H.: Management and Scientific Manpower; pp. 46–8. In U.S. NSF: *Proc.,* N 600.
657. Thomas, H. M.: Establishing the Proper Climate for Creative Effort; in *Creativity,* N 600, pp. 15–21.
658. Hebb, M. H., & Martin, M. J.: Freedom of Inquiry—the First Requirement; in *do.,* pp. 22–7, p. 24.
659. Nelles, M.: Deliberate Creativeness in Sci. & Engg.; *Chem. Bull.,* February 1953, or *Chem. & Engg. N.* 31:1520–3.
660. Price, Geo. R.: How To Speed Up Invention; *Fortune,* November 1956, pp. 150ff.
661. Machlup, F.: Can There be too Much Research? *Sci.* 128:1320–5, 1958.
662. Dedijer, S.: Measuring the Growth of Science; *Sci.* 138:781ff., 1962. Compares R&D also per capita and per horsepower developed.
663. Price, D. J. deS.: *Sci. Since Babylon,* 1961, chap. 5.
664. UN Dept. of Social Affairs: *The Question of Establishing UN Research Laboratories;* 1948, 290 pp.
665. Pub. Law 6101 of 1960.
666. *Nuclear Sci. Abstr.,* pub'd papers and books by Americans, excluding Govt. repts., mostly Amer. and not pub'd, and pats. The Amer. share was 54% in 1950, 40% in 1955, with the exclusions 1.07 times the counted American; and 27% in 1960, exclusions 1.52 times these. There is considerable duplication of our other Abstracts; but *Solid State Abstracts* and its predecessor *Semi-Conductor Electronics* were not used, and the numerous unpublished Amer. repts. 1960 figure is 5,060 pub. papers by Americans.
667. Administration Pushes Research Program To Aid Lagging Industries; *Wall St. J.* Mar. 13, 1963, p. 1ff.
Private Industrial R&D Gets Fed. Aid; *Chem. & Engg. N.* Feb. 4, 1963, p. 30.
668. Sen. Subcom'ee on Pats. etc.: *Pats., Trmks. & Copyrights,* Rept. of Apr. 3, 1963, 14 pp., pp. 3,6.
669. Schon, D. A.: Champions for Radical New Invs.; *Harv. Bus. Rev.* 41: March 1963, pp. 77–86. P. 80 for ¶ 400 and p. 77 for ¶ 623.
670. Solo, R. A.: Gearing Military R&D to Econ. Growth; *Harv. Bus. Rev.,* November 1962, pp. 49–60. charts, esp. B, and explanations, esp. pp. 52,6.
671. From NSF: *Amer. Science Manpower, 1960,* table 6, and cf. table A–3; and from NSF: *Scientific Manpower Bull.,* No. 19, December 1962, table 11.

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