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RESEARCH AND INVENTION IN ENGINEERING COLLEGES[1]

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RESEARCH AT ENGINEERING COLLEGES

THE practice of engineering can only be kept up to date through research. Engineering research has among its major objectives the development by scientific means of new manufactured products, more efficient machines and tools, special mechanisms and devices, improved meters and instruments, better manufacturing processes and more economical methods of operating equipment. Industries that have made the most spectacular progress are also foremost in research. Research is an integral part of any organization interested in efficiency, in long-range goals and in linking the present with the future.

[1] Address of the vice-president and chairman of the Section on Engineering, American Association for the Advancement of Science, Columbus, Ohio, December 28, 1939.

No very clear-cut line can be drawn between scientific and engineering research, although the latter is more generally concerned with the results of immediate economic value. It is also difficult to differentiate between research and development.

Research in higher educational institutions is being supported to a considerable extent by industry and government. Industry recognizes that the research specialist at an educational institution is working in an atmosphere which is sympathetic to research and free from interruptions. The efforts of the research worker in an educational institution result not only in new knowledge but also in improving the main product of education—the students. In the past there has always existed a definite gap between the successful completion of a scientific research project and the utilization by industry of the results secured.

This gap is being greatly reduced by cooperative research, which brings together most effectively the talents of the university and of industry. There is a constantly increasing amount of research being carried on by American industry in cooperation with educational institutions, research foundations and government bureaus. The results secured by industry through research, in cooperation with selected engineering colleges, indicate that such educational institutions can undertake and carry out successfully research projects of considerable magnitude and of benefit to industry as well as to engineering education. From the earliest days of our national existence the United States Government has conducted investigations, of a greater or lesser scientific character, in order to establish a sound basis for its legislative and administrative activities. Investigations in agriculture predominate among the fields of governmental research. Next to agriculture comes research for improved public defense. Outside of the field of agriculture practically no support has been given by government to research in higher educational institutions.

The Supplement to the *Journal of Engineering Education,* published in February, 1931, reports the status of research in engineering colleges during the year 1928–1929. During that year $2,156,863 were expended by the engineering colleges of the United States of America, and provided for the employment of 575 full-time and 807 part-time research workers.

The engineering colleges in the "land-grant" group, which represents about one third of the engineering colleges of this country and nearly one half of the engineering student enrolment of this country, had available during the year 1939–40 a total of $1,802,263 for engineering research, which was being carried on by 251 full-time and 450 part-time workers, in addition to 383 teachers who were devoting time to research without extra compensation. $962,267 of the funds expended for engineering research at the land-grant institutions during 1939–40 came from industry.

Inventions and Patent Policies

Reasons for Patent Policies. Research at educational institutions may lead to improved processes, machines, chemical compounds or articles of manufacture of potential industrial and commercial value. Thus, educational institutions found it necessary to consider patent policies in order to encourage inventive talent on the part of their staffs and students, to protect industries cooperating with them, but particularly as a protection to the institutions themselves which ordinarily do not have the facilities to administer patents and usually consider legislation and business details in handling patents entirely outside of the jurisdiction of their governing boards. In state-supported institutions the administration of patents and special payments to inventors often involve legal restrictions. Some state universities take the stand that a state institution supported by public funds has an obligation to reserve for use of the public all benefits accruing from investigations made by its staff members or others under its control. Such institutions reserve the right to all discoveries and inventions which are the direct result of the staff members' regular duties or at the expense of the university. Inventions developed outside of their regular duties or at their own expense are not the property of the university.

Research Foundations. There is a definite trend for universities to turn over their patent problems to the Research Corporation of New York, or to set up research foundations of their own, which finance research and to which the inventor assigns all rights of his research findings. Such institutional research foundations are non-profit corporations organized for the purpose of encouraging creative talent by relieving the inventor of the financial burden and loss of time from his research interests and by financing research from profits accruing from the sale or royalty on patents. The charter of such foundations usually includes a clause which authorizes them to accept "all rights and titles to inventions, and in order to protect, defend, dispose and/or arrange for the discovery or invention by members of the staff or students of the institution" affiliated with the foundation. Research foundations are granted by their charters the freedom to accept gifts. Research foundations are in a position to aid educational institutions in sharing patent rights with industry, a common practice in many industries which even license their direct competitors.

The Research Corporation of New York is the outgrowth of Dr. Cottrell's interest in the development of science and its applications. For a number of years the Research Corporation of New York concerned itself mainly with the development and installation of Cottrell Precipitators. However, the field of endeavor of this foundation has been broadened into many scientific fields, and it has taken over the handling of patent problems in educational institutions. The net earnings of this foundation are used to encourage scientific investigation.

The research foundations at universities have usually been developed as the result of an invention by a member of the institutional staff and by reason of the growth of research in cooperation with industry at educational institutions. Thus, the Cornell Research Foundation, Inc., was started after a member of the agricultural staff discovered a patentable process. At Purdue University inventions of commercial value, developed in its agricultural and engineering experi-

ment stations, led to the creation of the Purdue Research Foundation. At Wisconsin several of its alumni became interested in Dr. Harry Steinbock's discoveries relating to the use of ultra-violet rays to enrich the Vitamin D content of foods for medicinal products, and the Wisconsin Alumni Research Foundation resulted with its major objectives, "to promote, encourage and aid scientific investigations and research . . . and to assist in providing the means and machinery by which scientific discoveries of the staff may be developed and patented, and the public and commercial uses thereof determined."

Former Reports on Patent Policies of Educational Institutions. A report by a Committee of the Association of Land-Grant Colleges and Universities on Uniform Patent Practices was made on November 22, 1922, and published in the *Proceedings* of the thirty-sixth annual convention of this association (pages 283–284). This report includes the following suggestions with reference to patent policies of state institutions:

(*a*) That an institution has a right to inventions or discoveries made by the members of its staff incident to their regular duties or at the expense of the institution.

(*b*) There may be cases where the inventive genius of the investigator, while helped, no doubt, by his surroundings in the experimental laboratory, nevertheless would have evolved the same idea under circumstances where there would be no question as to it being his property. There would be other cases where, without question, the investigator could not have any moral claim personally to the ownership of the patent. Therefore, it would be rather difficult to make any hard-and-fast rule but what would work some injustice one way or the other. In any case the inventor should have some equity in the patent, but so should also the institution.

(*c*) That the main reason for securing patents on inventions is to prevent an outsider from pirating them at the expense of the public.

(*d*) The possession of a patent implies an obligation to utilize the invention for the benefit of the public. If there is danger that the patent will be filed away "under a bushel" it will be better for the institution to forego its right to inventions.

(*e*) Several were of the opinion that the inventions or discoveries made by members of engineering experiment station staffs should be made available to the public without restriction. Alfred D. Flinn, later secretary of the Engineering Foundation, brings out the fact that: "A patent *given to the public* is often most effectively withheld from the public, because no one would assume the business risk and the development expense necessary to commercialize an article over which he can have no control for a reasonable period." Only patents which have no commercial value may be properly dedicated to the public.

(*f*) The question of disposition of the patents is a most difficult problem to solve. If manufacturing rights would be granted to all who apply, responsible business concerns would not be interested. Educational and research institutions are not in a position to do commercial business, such as would be involved in owning patents, to defend the patent owned or even to negotiate successfully for the disposal of rights under patents. Unbusinesslike methods in handling patents by educational institutions would hinder rather than promote discoveries or inventions. It will be necessary to have some outside organization handle the details with reference to the disposition of the patents. The Research Corporation of New York was organized to handle patents of those who are not in a position to exploit them. In time the various engineering experiment stations may accumulate a sufficient number of patents to justify the organization of a central clearing house for the administration of such patents.

The *Journal* of the Patent Office Society for February, 1934, issued a publication by Archie MacInnes Palmer under the title "University Patent Policies." The following summary of this publication is of interest:

> Most of the research conducted at educational institutions, being primarily concerned with the extension of knowledge, is not utilitarian in view. Nevertheless, the efforts of research workers, especially in the applied sciences, frequently result in discoveries of probable, if not immediate, application.

In order that the public may derive the most good from such discoveries the educational institutions should in most cases patent the applicable results of research and direct their commercialization in an unexploitative manner. In very few cases does it seem wise to dedicate a discovery to the public.

Among the legal, administrative and ethical problems are those involved with the obligations to the public, the inventor, the industrial donor in cooperative research and the educational institution. The procedures and policies followed by universities in this country in handling these problems vary considerably.

The following patent policies reported in the Palmer bulletin are of interest:

At St. Louis University a faculty-composed Committee on Grants for Research handles patent problems and is authorized to make agreements with licensees, control the standardization of the product being made under the license and distribute the income from the patents.

At the California Institute of Technology it is the practice for any staff member, who in connection

with his research makes a patentable discovery, to assign the patent to the institute. Such action, however, is taken only when the officers of the institute think it expedient in the interest of C. I. T. The disposition of any proceeds is left to the Board of Trustees.

At the University of Toronto the governors of the university have been empowered with all the necessary authority needed for securing and administering patents. The staff member is not forced to assign his rights to the university; the facilities are merely offered staff members for their own volitional use.

At the University of Cincinnati an Institute of Scientific Research was organized in 1920 "to provide a separate unit for research in any distinctive field or for combined research in various fields." Under its management at least three separate research foundations and accompanying research laboratories under university supervision have been set up in specialized fields.

The University of Utah has made plans in 1934 for the organization of a research corporation, since the university is prohibited by law from exploiting the fruits of its research.

Present Patent Policies of Educational Institutions. The principal aspects in regard to present patent policies and practices of educational institutions were secured from 39 universities, colleges and technological institutes which included twenty-five state institutions and fourteen privately endowed universities and technological institutes. This list was made up of the state universities of California, Florida, Georgia School of Technology, Illinois, Iowa, Iowa State College, Kansas, Kansas State College, Kentucky, Maine, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, North Carolina State College, Ohio, Oregon State College, Pennsylvania State College, Purdue, Texas A. and M. College, Virginia Polytechnic Institute, Washington State College, West Virginia and Wisconsin. The privately endowed institutions included Carnegie, Case, Columbia, Cornell, Harvard, Lehigh, Massachusetts Institute of Technology, New York University, Pittsburgh, Princeton, Rensselaer Polytechnic Institute, Stanford, Stevens and Yale.

These aspects may be summarized as follows:

Twelve of the above institutions have no patent policies. These include the Case School of Applied Science, North Carolina State College, Rensselaer Polytechnic Institute, Stevens Institute and the universities of Iowa, Kansas, Kentucky, Missouri, Nebraska, New Hampshire, Pittsburgh and West Virginia.

Research foundations have been organized at seven institutions, which include Cornell, Minnesota, Ohio State University, Purdue, Virginia Polytechnic Institute, Washington State College and Wisconsin. The University of Maine is in the process of adopting a policy which will include a research foundation.

The University of California, the Massachusetts Institute of Technology and Princeton University have arrangements so that all business matters of any invention are handled by the Research Corporation of New York upon the recommendation of an institutional patent committee. New York University has no policy at present but is exploring a modified type of contract with the Research Corporation of New York.

The Carnegie Institute of Technology at Pittsburgh is now formulating a policy for the entire institute; but in its two research divisions, concerned with coal and metal investigations, the research staffs are at present under written agreement to assign all patents to the institute. This requirement does not apply to professors outside of the coal and metal research laboratories. In the case of the Coal Research Laboratory patents are held in the name of the Carnegie Institute of Technology and are administered by the Institute Board of Trustees. Patents are licensed to each of the contributing companies without cost until such remission of normal license fee shall amount to twice the total contributions made or ten times the annual contribution in the year in which the patent is granted, whichever is the greater.

Columbia University in the City of New York has a corporation controlled by a board of trustees which offers its facilities to members of the faculty in securing and administering patents, provided, in the judgment of the board, a patent is desirable in the public interest.

The University of Florida has at present under consideration a patent policy under which patents will be administered by a research council of staff members and applicable to investigations financed by the university or by an agency cooperating with it.

Harvard University is interested only in patents of its staff members which have therapeutic value. Patents of professors outside of the medical faculty of Harvard University are considered to be the private affair of the inventor.

Iowa State College handles the legal and administrative details through a joint patent committee of the college and the Iowa State Board of Education. A similar policy is found at the Georgia School of Technology where patents of staff members and students are assigned to the Industrial Development Council, a corporation of the State of Georgia which administers patents in its trust.

The University of Illinois controls all patents and under its rules requires the assignment to itself of all discoveries made by members of its staff in the course of their researches as such members, whether the research be financed from private sources or

otherwise; all patents thus acquired are controlled by the university. The application for patent is made by the staff member, and the patent is assigned to the university, which grants licenses exclusively or non-exclusively, according to the circumstances, and gives preferential consideration to private sources financing a given research. The university deals liberally with the inventor and pays him a substantial portion of the earnings from patents, after all expenses have been paid. Lehigh University has its staff members assign to the university patents resulting from cooperative research, and the royalties are equitably divided.

The patent policy of the University of Michigan involves the assignment to the regents of the university only those patent applications with inventions resulting from research projects financed by the university or by some party under contract with the university. The cooperating agency is given a non-exclusive free license to any patentable inventions which it finances. The client, however, may also elect to take full assignment and be responsible for the preparation and prosecution of the application. The university has no incorporated research foundation, but handles directly all legal and business details regarding patents.

The Pennsylvania State College requires all staff members engaged specifically to do research to assign to the college all patents resulting from their assigned duties. Other staff members are not so bound by contract, but are advised to assign patents to the college only on the occasion that the Council on Research judges that the college obviously has an equity in the work from which patents resulted. The college pays the cost of obtaining such patents and the board of trustees may transfer all rights to the Pennsylvania Research Corporation (or similar organization) for administering the patents.

At Stanford University a patent committee of the institutional faculty and administration receives reports of discoveries by staff members and students. Inventions found valuable are assigned to the university upon the recommendation of the patent committee to the president. When researches are of a cooperative nature, patent interests and rights are shared equitably with the donor in proportion to the relative contributions.

At Yale University patent matters are referred by the president to the prudential committee of the corporation which is authorized to deal with each case according to its merits.

At the State Colleges of Kansas, Oregon and Texas institutional policies with reference to patents are under consideration.

It is a policy of educational institutions not to acquire inventions other than those developed by its staff members and students.

Arrangements regarding royalties differ. Most institutions have no definite commitments. In some universities a percentage of the gross or of net earnings, 7 to 10 per cent. of the gross earnings and 15 to 50 per cent. of the net earnings, is paid to the inventor. Each case is treated separately and with particular care that equitable rewards are accorded to the inventor. At the same time recognition seems to be given to the fact that "our patent laws were enacted to encourage the development of the industries for the benefit of the public and not to reward the inventor.[2]

Those institutions which issue licenses on their patents usually determine the royalty basis in accordance with the estimated commercial possibilities of the invention, the prevailing rate in industry, whether or not the licensees financed the research project from which the patent resulted and value of the invention in connection with national defense and general public interest. Few institutions seem to feel that industry has the sole claim on patents resulting from research which it finances. The usual practice is to grant non-exclusive licenses only under conditions and restrictions calculated to produce maximum benefit to the public with due fairness to the industry which financed the research program. In some cases a moderate royalty is expected for use in development and production, as well as a certain amount of control.

Few universities and colleges have any positive policy or interest in participating in cross-licensing or patent pools; only two reported having any connection with a patent pool. Thus, at the Georgia School of Technology one case of cross-licensing, provided for the exclusive handling of licenses by the Industrial Development Council, a state corporation handling the patent problems of this institution. The University of Minnesota has entered into a partnership which might be designated as a patent pool to cover a certain specific place already occupied by a company of national and international importance in the field.

There seem to be two different policies regarding patent litigation and the defense of patent rights. Where patents are handled through the Research Corporation or through a research foundation affiliated with the educational institution, the general policy is to avoid aggressive action but to defend all clear rights even to the extent of court litigation. Some foundations insist in license agreements that the licensee as-

[2] Special Publication of the American Association for the Advancement of Science. Supplement to SCIENCE, 79, No. 1, January, 1934.

sume the expense (in part, if not all) of patent litigation. When patents are administered by the governing boards of universities and colleges, legal and political implications usually govern the actual procedure.

Sixteen educational institutions, which have cooperated in this study, report 380 patents, of which 114 are in active use. Only one university dedicated an invention to public use mainly because of its simplicity. Only five educational institutions report income from patents.

Patent policies of educational institutions apply to inventions in the public interest, inventions resulting from researches in cooperation with industry and inventions resulting from research at the expense of the educational institution. No other country in the world offers to creative genius the incentive and opportunity which are afforded by the patent system of the United States of America, provision for which was made 150 years ago in the Constitution of this country. Our patent system vitalizes and perpetuates the stimulus to invention without which technical progress would have been stifled by secrecy and selfish motives. Without question the American patent system is a major contributing factor to the industrial supremacy of America. American industry is dependent for its future progress upon our patent system, which has provided a stimulus to inventors and a protection to capital which has backed creative effort. Educational institutions can not expect to secure from industry large sums for research unless the discoveries from such investigations are protected by patents. Industries expect protection from exploitation by their competitors.

There is a general consensus of opinion that commercially valuable discoveries should not be dedicated to the public but should be patented. As Dr. Elihu Thomson has said,[3] "publish an invention freely, and it will almost surely die from lack of interest in its development—patent it, and if valuable, it will be taken up and developed into a business."

Among those institutions which have no definite patent policy there is found in some cases an attitude that an educational institution has no right to become involved in patent business, but that an invention belongs only to the inventor. In many cases authorities feel no need for a special patent policy, either because the researches in such institutions have not yielded results of particular commercial value or by reason of their interest in theoretical or basic research. In a special publication of the American Association for the Advancement of Science, Supplement to SCIENCE, Volume 79, No. 1, January, 1934, the objections to patenting, not only by institutions, but also by scientists and professors, were based on ethical and moral grounds as well as interference with research. Those objecting to an interest in patents on the part of scientists claim that patenting requires secrecy on the part of the research worker and leads to the debasement of research and to ill-feeling and jealousy on the part of the colleagues. On the other hand, the social and economic advantages that accrue from patenting the results of research that have potential commercial and industrial value far overshadow the objections mentioned.

Conclusions. Educational institutions of higher learning have produced in their research laboratories discoveries and inventions of value and importance to industry and agriculture. Not until comparatively recent years, however, have colleges and universities realized that their technical research programs would better serve mankind if commercial and public needs were strongly considered in their planning and if the cooperation of industry were available. In making the products of the laboratory available to society, colleges and universities have found that dedicating the findings of research to the public actually withholds these findings from use. Likewise, industry is very reluctant to invest in cooperative research unless patent rights are obtained for the results of research allowing adequate protection for the commercialization of the new findings. For these reasons it has been found that educational institutions operating their research programs under definite patent policies are in the best position to enhance technical progress.

Formal arrangements with staff members regarding patents usually apply to cases of research programs financed entirely by the university, college or institute or by some outside agency or donor in connection with cooperative research programs. Inventions not financed by educational institutions or by agencies cooperating with them are the property of the individual teacher or research specialist. Where research foundations have been established they are available for use by staff members in connection with their own inventions. Equitable sharing of ownership is decided upon in instances where others have a legal right to a share in the new finding. In cooperative research, even if it is financed entirely by industry, the resulting patents are assigned to the educational institution which, in turn, usually shows special consideration to the donor in the matter of licensing. The securing and administering of patent rights is considered by the governing boards of many institutions to be outside of their jurisdiction, and in state-supported colleges and universities much caution must be taken in the handling of patent matters to avoid legal difficulties. In meeting this situation, seven of the thirty-nine educational institutions, contacted in the study, have organized research foundations for administering desirable patent policies, while one other is planning such action; three have entrusted the handling of patent matters to the Research Corporation of New York,

[3] *Electrical World*, 75: 1505, 1920.

and a fourth is considering the adoption of this procedure; in two other instances a state board is given the responsibility for patent administration; patent policies and problems in thirteen other educational institutions are under the jurisdiction of faculty committees and/or governing boards. Twelve schools have not as yet organized or have not felt the need of formulating a definite patent policy. Thus about two thirds of the institutions investigated have a definite patent policy, and these include the institutions which receive the greatest support for research from industry. There is apparently no difference in the actual practice of state-supported and privately endowed institutions. Nearly as many have patent matters administered through research foundations, or the Research Corporation of New York, as through institutional governing boards.

Those universities and colleges which have definite patent policies are of the opinion that both the social and economic welfare of the public are being enhanced by their methods of handling patents and of encouraging creative activity of their staff members. Unexploitative commercialization of patents is of definite value to the public. Earnings from patents are used to reward the inventor and to support research.

The procedure of utilizing the personnel and equipment of educational institutions in cooperative research with industry is sometimes looked upon with doubt and disapproval. Colleges and universities often are prejudiced against cooperative research because of the legal and administrative problems involved, precedent and policy of governing boards and moral and ethical principles. On the other hand, industry is often skeptical of cooperative research on the grounds that educational institutions are too unbusinesslike and too theoretical in their research activities. The initiative in bridging the gap between the two groups can be taken by colleges and universities in formulating and administering patent policies designed to remove the difficulties and misunderstandings retarding cooperation between industry and educational institutions.

The fact that the income accruing to educational institutions from patents is insignificant indicates that the incentive for discovery and invention in colleges and universities is not financial reward but is involved in the fair and equitable recognition of creative genius and of aid given by industry to research. Scientific research is the main concern of higher education with reward to the institution and inventor as a secondary consideration. Inventive ability is placed on the same level as good teaching and good relationship with the public, and the creation of new scientific knowledge is recognized and rewarded. Industries cooperating with educational institutions find that a considerable number of colleges and universities through a sound patent policy are in a position to protect the findings of the research laboratory, while encouraging creative talent and reward for accomplishment.

PHYSIOLOGICAL ALTERATIONS AS THE CAUSE OF SENILE DEBILITY AND SENILE MORTALITY[1]

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SENESCENCE is characterized by two outstanding manifestations increasing debility and increasing death rate. Of the two, debility seems to cause the greater concern to the average individual. The data discussed in this paper indicate that both these manifestations of senescence may result from the same physiological alterations.

When the logarithm of the probability of death (log P_t) is plotted against the age of the individual (t) a straight line curve after the age of 35 is obtained. This may be expressed by the equation:

$$P_t = P_o\, e^{kt} \qquad (1)$$

where k is a positive constant and P_o is the (extrapolated) probability of death at the time of birth. This is another way of expressing the law of Gompertz,[2] which was published in 1825. For total deaths in 1936 from all causes k is equal to 0.078, which means that the probability of death increases 8.1 per cent. each year in a manner analogous to the accumulation of compound interest.

Most of the diseases[3] (namely, groups A and B in

[1] This investigation has been aided by grants from the Josiah Macy, Jr. Foundation and the John and Mary Markle Foundation.

[2] B. Gompertz, *Phil. Trans. Roy. Soc. London*, 1825. For a discussion of attempts to interpret the biological significance of this and other equations, see Bernstein, *Symp. Quart. Biol.*, 2: 209, 1934. See also A. Putter, *Naturwissenschaften*, 8: 201, 1920, and K. Kupfmuller, *ibid.*, 9: 25, 1921. An equation for "loss of vitality" was used by S. Brody (*Jour. Gen. Physiol.*, 6: 245, 1923). "Vitality" was the reciprocal of "Mortality," so that k was negative. This was applied to egg-laying and to healing of wounds.

[3] E. B. Nathan (*Trans. of the Faculty of Actuaries*, 10: 45, 1924) stated that diseases can be classified according to whether or not they follow Gompertz's law or Makeham's modification of that law. Our data, from a different country and decade, are in general agreement with Nathan's in that the following diseases do not obey equation (1): accidents, tuberculosis, infancy, childbirth, congenital malformations and chronic alcoholism. The reasons are obvious, except for tuberculosis and alcoholism.