for merely material things and so must be changed. We may sometime settle back in static and dynamic equilibrium, each one busied with his neighbor's laundry. But before this is done, we here expect that competent research men will in general receive pecuniary rewards approaching those of men who merely "sell the stuff." There is a healthy tendency in that direction. However, this talk is not an appeal to the public for higher salaries, but rather an attempt among ourselves for better understanding of what constitutes encouragement.

Industrial research is an expression of the advanced and advancing state of American minds. This is true not only of the industries but also of the research men themselves. Nothing seems established except this forward movement. It is what Kettering, of General Motors, might call a "perfectly satisfactory unsatisfied, but not dissatisfied state."

The obvious way to encourage is by encouragement, but encouragement has never been standardized. Coin is a token and performs useful functions, and salaries of research men will continue to rise. The accumulated research of an inventor's lifetime used to be sold for what it would bring under a forced sale. Novel processes and new ideas were produced by millions (there are nearly two million American patents), but not one per cent. of the hard-working inventors were ever rewarded at all. They worked under heartbreaking disadvantages and carried the entire risk of their ventures. The public would have been well justified in sharing the risk with competent workers. Later it seemed more promising to grubstake the inventor, and this was quite generally done. Many lines of industry were built about a single experimenter. The more recent scheme is to stake groups of trained and selected investigators and combine their work so that new results may be continuous. This is now a tested development. It is easy to see its advantages. On the whole, it costs the public less and produces better results than the shiftless way of rewarding the occasional inventor who ripened his product on the day the market was exactly ready, while declining even to feed the poor fellow who was far-seeing and got ahead of the procession.

But the unlimited use of coin alone does not guarantee satisfaction anywhere, and we are thus led from the subject of salary, in which no one is expert, to the conclusion that the adequate compensation for encouragement to continue research must include those tokens of appreciation which other creative people generally desire. This is a strong survival principle for a race. Publication in some form to bring recognition by one's peers is the nearest equivalent to the artistic painting, the beautiful poem, the enduring sculpture and the splendid architecture of other creators. The most altruistic and far-seeing leaders realize the importance of this encouragement, and even those who have never analyzed it instinctively feel its value.

Another token of research appreciation, strange as it may seem, is further opportunity for more and better work. The research man must progress. In the industry this means improved facilities, new apparatus and enlarged activity of all kinds. Every good research man wants to work with new and improved tools, and this includes everything, from freedom from interruption to added assistants and floor space. If this encouragement is criticized as not being a token of appreciation, I can only say that it is a weighty matter of experience.

WILLIS R. WHITNEY

RESEARCH LABORATORIES,
GENERAL ELECTRIC COMPANY

IS RESEARCH A GAMBLE?

RESEARCH is good business when run on a business basis. Scientific study of an industry from every angle will pay for itself in the new knowledge gained. If new products or new processes come out of such research, then is the time when one may expect to begin to spend money. The development that must follow research if successful production is to come later may cost many times as much as the original research, with a chance that all may be lost. A good research business man takes no blind "fliers," but first feels his way, making his mistakes on a small scale rather than later on a large, manufacturing scale. Thus is the chance for failure reduced to a minimum, provided resources are not exhausted by too large a venture or too many new development projects at one time. Industry must engage in research or fall behind in the race to-day. Intelligent, persistent research and development is bound to win in the long run. If all is not staked on one idea and a few experiments, the law of averages will remove most of the gamble. The successes may not be along the lines of first endeavor; they may be even greater than at first thought possible; but they must at least earn enough over the returns from standardized, competitive industry to warrant the risks and the expensive delays incident to all industrial development.

L. V. REDMAN

RESEARCH IN THE ENGINEERING COLLEGES[1]

THERE are significant differences of national policy concerning the character of the higher schools of engineering and their function in the social order

[1] Read before the Section of Engineering, American Association for the Advancement of Science, New York, December 29, 1928.

which can be understood only in the light of their historical backgrounds. Fifty years ago Dr. C. O. Thompson, the first president of Rose Polytechnic Institute, observed from his studies of the engineering schools of Europe that there had been little change in their essential character after the first ten years of their existence. It appears that the character of institutions, like that of persons, is largely conditioned by heredity and early nurture. Later growth is more often a maturing than a formative process. Those who know the American colleges of engineering well are aware of the grip of historical tradition which is always more of a ruling force in institutions directed by legislative action, such as colleges, than in industry and other institutions where executive authority prevails.

It may be profitable to spend a moment in a brief review of our national types. Education for the technical professions had its origins in France. The early schools developed within the technical services of the state. Their aims and spirit were exclusively professional. Later the École Polytechnique was created to assure a high intellectual formation in advance of professional training proper. These early institutions had no organic connection with the university system. Their exclusive aim was to provide a *corps d'élite* of engineers for the state and industry. They were strictly teaching institutions, staffed by practitioners and savants whose major interests were elsewhere. The character of the professional teaching was notably high, and many of the teachers were men of great creative genius, but their creative activities were largely done off the premises. The influence of the so-called *grandes écoles* of Paris was world wide, and not least in America. In France itself they fixed a norm of technical education which is still dominant. Their professional discipline is notably thorough, but the professors give only a part-time service, graduate students are unknown and research is largely a stranger to their precincts. A new type of organization has been growing up in the past thirty years in a group of *instituts techniques* in the provincial universities. While they have been deeply influenced by the strict professional traditions of the *grandes écoles* of Paris, their attachment to the faculties of science has worked in another direction. They have a fair proportion of full-time professors and an active research spirit. Graduate students in French technical schools are rare, almost to non-existence. Provisions of the award of the doctorate in engineering for researches in the universities have only recently come into effect. In general, the place of research in French engineering schools is incidental, secondary and indirect. France has almost the entire distance to travel in making it a primary force.

The historical genius of British technical education must be sought in a welfare movement for workingmen. Industry, scientific inquiry, higher learning and professional training grew up in separate compartments of British life, and the barriers have not yet been completely leveled. The pioneers of British engineering and industry were workingmen and it was assumed that a succession would arise by sheer force of native ability, helped on by incidental scientific instruction in evening schools. This idea dominated by far the greater part of British technical education until nearly the end of the last century. The idea of creating a highly trained professional personnel to apply science to industry was largely alien to British thinking in that period. Meanwhile the engineering schools in the university system struggled along against odds of hostility and neglect. The last forty years have greatly changed this situation; industrial competition, chiefly with Germany and America, and the recent war, awakened Great Britain to the greater effectiveness of professional scientific effort. University schools of engineering have been greatly strengthened. The fact that there are two quite distinct types of technical schools has led to a fairly definite division of function. The so-called technical institutions, heirs to the early welfare movement for workmen and controlled by local education authorities, serve the local population and industries in a most direct manner through their part-time and evening instruction, and provide fully nine tenths of the technical recruitment. The university schools of engineering, on the other hand, devote themselves to general and fundamental, rather than local and immediate needs. They are small units, with an average of less than three hundred students. There are few full professors, and they are selected for their scholarly distinction rather than their activity as practitioners. The possibilities of specialization are very limited and the schools work at fundamental things both from choice and from necessity. Research has taken a firm rootage in this soil and found it fertile. The crop is choice, rather than large. Much of the research in progress is less specialized and in that sense less advanced than that which abounds in Germany. There is little direct cooperation with industries, but a large share in the work is initiated by national agencies, and it aims to be fundamental in the highest degree. The universities are not first-aid stations for British industry, nor are they convenient service stations for routine tests. There is little or no confusion about the aims and nature of research.

Germany is the land of technical research, *par excellence.* The resurgence of the German states after the Napoleonic era was the historical miracle of the nineteenth century. There has probably been no other historical movement in which technical education and research have had so large an influence. Poorly endowed with natural resources and lacking capital for the upbuilding of industry, the German states turned to the creation of scientific knowledge and skill as the means of their economic salvation. In all the history of German technical education there appears the hand of statecraft, deliberately reshaping old agricultural regions into the modern industrial empire. The technical sciences began to gain a precarious place in the German universities late in the eighteenth century. Once the issue was clearly defined, the new disciplines were thrown out, as alien to the genius of abstract and disinterested learning. Statesmen came to their aid, Count Von Gerstner in Bohemia, Nebenius in Baden, Beuth in Prussia. It was necessary to begin with trade schools, then to build up a system of secondary education based on modern studies, and gradually to raise the status of a chosen group of polytechnic schools to the level of complete equality with the universities. This process occupied the whole of the last century. In the last half of the period the attaining of a university status became a major issue, and the form of university organization and work became a strong molding influence on the *technische Hochschulen.* The *Verein Deutscher Ingenieure* put the whole weight of its influence behind the movement. To this end it encouraged a complete separation of the higher, middle and lower technical schools, aided in the upbuilding of the *Realschulen,* raised funds to finance higher researches, drew the support of the industries to the *Hochschulen* and supported their demands for the right to award the doctorate. At the close of the century the equality of the *technische Hochschulen* and the universities was formally recognized by imperial authority. The effect had been to make the *Hochschulen* teaching institutions in a comparatively secondary sense, and to make their function the advancement of technical science and art. German industry was quick to follow the lead of the state and the profession in supporting the technical universities as the chief centers of creative effort. A brilliant example was set by the Krupp interests, who established the Kaiser Wilhelm Institute of metallurgical research at the *Hochschule* at Aachen, at a cost of over $400,000. Many examples could be cited of the policy of German industries of placing the ablest researchers in professorships and of giving them resources for creative work rather than drawing them away to more sequestered work under industrial auspices. Furthermore the policy has been quite consistently pursued of concentrating resources and support for research on selected men and institutions rather than scattering them indiscriminately. In addition to the institute of metallurgy at Aachen, prominent examples are to be found in Professor Rhebock's laboratory of hydraulic construction at Karlsruhe, Professor Becker's automative institute at Charlottenburg, Professor Nagel's center for research on piston engines at Dresden, the unique laboratory of X-ray technique at Stuttgart, Professor Knoblauch's Institute of Heat Physics at Munich, the laboratory for high-tension research at Darmstadt, the laboratories of machine tool technology at Hanover and Charlottenburg, and the institutes of psychotechnics presided over by Professor Möde at Charlottenburg and Professor Sachsenberg at Dresden. Statistics are not obtainable, but the ratio of doctor candidates to undergraduates in Germany appears to be quite as high as the ratio of all graduate students to undergraduates in American engineering schools, and as few American graduate students carry their studies beyond the level of the *Diplom-ingenieur* in Germany, the contrast is even greater than the ratio indicates. German technical universities are so large and their organization is so highly ramified that opportunity is created for a high degree of specialization. No doubt solutions are found for many more specific problems in consequence of this specialization, but it is not yet possible to say whether the ultimate contributions to progress are relatively greater than under the unspecialized conditions of Great Britain. The present degree of activity in Germany bears out the slogan of one of the German technical societies, *Die Technik ist Deutschlands wirtschaftliches Schicksal*—technical science is Germany's economic destiny.

Engineering education in the United States is an outgrowth of a popular movement early in the last century to promote "the application of science to the common purposes of life." There was no thought at the outset of creating any formal discipline for the profession of engineering. The aim was to give farmers and mechanics such a scientific education as would enable them to become skilful in their professions. Rensselaer had scarcely begun its pioneer work as a school of applied science when the advent of the railroad opened a new chapter in the history of American engineering. The engineers of the earlier decades, a scattered group of land surveyors, builders of roads, bridges and canals, and practical constructors of machinery, had been largely self-taught; with the railroad came a demand for engineers with a greater mastery of the scientific resources of the art. There was no existing foundation for a scheme of training by pupilage as in England, and the engineering school arose from simple necessity. The effort to apply science to the common purposes of life passed rapidly into the special form of a professional discipline for engineers. As there were no models in the English-speaking world, they were borrowed from France; with them came the conception of an engineering school as almost exclusively a teaching institution, with a strict disciplinary régime of work. The existing scheme of higher education was of a collegiate rather than a university character. Original scientific inquiry was uncommon. The scheme of engineering education was readily assimilated into the newly developing university system without changing its original conception that its function was to teach that art rather than to create it. For a long period the engineering schools had to face the charge of impracticality from the engineering profession and the industries. The traditions carried over from pioneer days, constantly reinforced by British influence and example, tended to emphasize the gap between theory and practice, to the mild disparagement of the former. The schools turned their effort toward making their training as practicable as possible. Shops and laboratories were introduced which simulated industrial practices. Professors sought to gain recognition of their competency by engaging in collateral practice. The teachers had practically no fundamental training beyond the four-year undergraduate course. American authorship was largely a process of compiling and editing. To get hard work out of their students teachers of engineering worked harder than their academic colleagues in the same proportion. There were here and there inquiring minds which attacked original problems out of native curiosity, but with little encouragement from the engineering profession and the industries and not much more from the educational authorities.

With the development of the field of electrical engineering in the eighties, followed by chemical engineering in the nineties, and with the gradual infiltration into American schools of men trained in Germany, engineering education began to swing away from its effort to be practical to an effort to become scientific. Many of the professors of these new branches had not been trained as engineers, but as physicists and chemists. Their assimilation to engineering enriched and fertilized it with a new scientific spirit. A bond of understanding sprang up between the schools and the new industries which traced a direct descent from scientific research and technique, whereby the employer took all the responsibility for the practical training of the graduate, and left the school free to devote all its energies to his scientific formation. Conditions began to be favorable to research in engineering colleges about 1900. Previous to that time there had been few men in the engineering colleges who had either the interest or the qualifications to pursue it, and the physical facilities had been planned with little regard to it. Meanwhile the tradition had been seventy years in the building that teaching is the chief, almost sole business of the college, that only practical experience and professional reading were needed to qualify the teacher beyond his own undergraduate training, and that collateral practice had the first claim on the spare time of the engineering professor. Research activity gained headway slowly against the inertia of this tradition. Accelerating forces from the state, the engineering profession and the industries, so marked in Germany, were conspicuously lacking. The movement had scarcely gotten under way when American industry waked up to the potency of scientific research as a competitive weapon. Great industrial laboratories arose and the world was scoured for men to man them. Industry had apparently little compunction in drawing the most promising investigators away from the colleges for its own private needs. Considering the limitations under which research in engineering colleges must be conducted there can be no doubt that the productivity of the individuals concerned was greatly increased through the transfer. The seriousness of the matter arose from cutting off the potential supply at its source.

Since the turn of the century the growth of research and quasi-research activities in the engineering colleges has been marked, yet in comparison with the growth of research under industrial auspices it seems that the colleges have relatively lost ground. A fairly complete survey of research activities in engineering colleges made in 1924–25, showed that fifty-eight, or about 40 per cent., had organized arrangements for research, at least on paper. Included in this number were forty-one institutions which have organized plans through which the services of the engineering staff are made available in consulting capacities to industries, public service utilities and others. If we include all institutions where research is fostered on a purely individual basis, the total rises to 110, or about 70 per cent. of the whole group. The total expenditures of the organized research departments in 1924–25 were close to $1,500,000. Of such expenditures, approximately 11 per cent. represented direct appropriations for engineering research by the several states, 40 per cent. funds allotted by the colleges from their general funds and 49 per cent. funds derived from outside sources, principally from public professional and industrial organizations. About 70 per cent. of this expenditure was made by nine institutions. At least thirty-four institutions reported full-time research staffs, with a total of between 250 and 300 men so engaged. To this number may be added 350 more who rendered part-time research service for definite compensation and about 200 who gave part-time service without special compensation. The numbers engaged on an individual basis can not be estimated.

These totals seem impressive. Their chief value is that of an index. It must be remembered, however, that in the same year two corporations in the electrical industry both spent more than double the total outlay of the engineering colleges on research activities and that at least two in other industries spent more than this total. Recent data on the research expenditures of industrial concerns, collected by the Division of Industrial and Engineering Research of the National Research Council show that at least six corporations are spending upwards of $1,000,000 per annum on research apart from all normal production. Returns from 800 concerns indicate an average outlay in 1927 of $44,500 for these purposes, or 1.3 per cent. of their invested capital. This amount represents a gain of 90 per cent. over the preceding year. Engineering colleges are spending an average of $10,000 apiece for like purposes. Furthermore, it would be very illuminating, if it were possible, to classify the expenditures of the colleges under such heads as actual research for fundamental knowledge, first-aid problems for industry, routine engineering testing, and what may be called quasi-scientific puttering. Confessedly the amount of real 24-carat research would be relatively small, for the reason that few teachers of engineering are capable of doing it or directing it. But then, the American attitude toward language is notoriously easy-going and we use the "word" research to mean so many things that we have no word left to mean "research."

In view of the contrast between the research activities of the colleges and those of big business, it is safe to assume that corporations at this end of the scale are not going to turn to the engineering colleges to get their fundamental problems solved. For one simple reason, they can not wait long enough. Furthermore, big business has discovered the publicity values of research. Big business can probably be induced to invest money in organized research in engineering colleges only on the plea that such activity is necessary in order to maintain the needful setting and staff for training the grade of researchers and engineers that big business requires. Industry is likely to reply that many of their most productive researchers are drawn from departments of pure science. In any case fundamental scientific research rather than engineering investigation seems likely to get the financial assistance from the source, and it will probably be disbursed through some intermediary or clearing-house instead of passing directly to individual colleges and professors. The campaign of the National Academy of Sciences for a national research endowment is working on this principle.

At the opposite end of the scale from big business are the innumerable small units of industry which live from balance sheet to balance sheet, with no consciousness of research needs and little margin for the support of such activities. When a small industry meets some acute problem outside the scope of its normal routine and staff, a college professor or laboratory may be a good place to turn for first aid, but this is scarcely research. Yet it is probably to industries in small units that colleges must look for resources to build up their research work.

Many of these smaller units of industry are concerned with the traditional arts rather than the applications of modern science. They are likely to remain deaf to any appeal to support research for the sake of repaying their debt to science or for the sake of maintaining a wide margin between pure knowledge and practical invention. It is just these industries, however, which are most apt to be handicapped by the decline of sporadic invention and likely to profit relatively most from an adequate program of research. Support for such investigation is not to be expected from the single units of such industries, but their state and national trade associations are the natural agencies to foster such activities. There are attractive possibilities of dividends in the form of better methods, economies and more exact control of the present state of the art. Research looking in advance of the present art is a form of mutual insurance covering the risks of supersession or revolutionary changes in the art.

A recent report of the Babson Statistical Organization announced that an English factory was testing out the production of a flexible, colorless, resilient, non-inflammable glass of organic origin. It went on to say:

> The point of this letter, however, is not only about glass. This is but one of numerous far-reaching discoveries which have recently been reported. We believe that business is entering an era of the most rapid and revolutionary changes in the chemistry and physics of manufacturing. To those who are quickest in taking advantage of such discoveries they present unlimited oppor-

tunities, but the manufacturer, merchant or investor who is asleep to these changes will be hurt.

The time has passed when advertising alone will get sales. The two best salesmen to-day are a "better product" and a "cheaper way of making it." Research opens the way to both. Furthermore, since the most deadly competition is not between concerns, but between industries, we urge clients to combine their energies with others in the same line of business. This saves duplication of efforts, leads to maximum results and keeps you best informed about all important developments. Make use of the help which the United States Bureau of Standards at Washington stands ready to give you, and also that of other technical organizations of high standing. Cease worrying about gaining the temporary advantage of exclusive patents, and combine your resources in the way that will do most to permanently help your industry.

(It is significant that the occasion which brought the above report to the writer's desk was a request from its authors for a complete list of the engineering colleges with facilities for organized research in cooperation with industry.) The writer is strongly of the opinion that trade and industrial associations offer by far the most promising agencies through which to promote industrial cooperation with the colleges in engineering research. The support of research by individual corporations is likely to be sporadic, while trade associations can effectively maintain a continuing relation. The results of work supported by individual corporations are apt not to be widely disseminated or used. A good deal of such support is frankly on a courtesy basis, without a vital interest in its effectiveness or utilization, and with little genuine collaboration between the college and the industry.

A trade association, administering its funds in trust for its constituency and genuinely concerned to show a good return for the investment, provides an excellent medium for the joint shaping of research projects and a widely ramified channel through which to disseminate results. It would seem that the most fruitful result may be expected when a trade association concentrates its cooperative program at a single college, or at a small group of institutions at most. Such work ought not to be located on a courtesy basis or split up on a political basis, but should seek to capitalize distinctive advantages of men, plant and environment. There is a definite loss when such resources are spread over many institutions as a fairly ineffectual mist, when they might be concentrated into a fairly powerful stream. In this respect the European situation is far better ordered than our own. The policy of concentrating resources abroad has led to the upbuilding of a group of notable and distinctive research centers which are the principal factor in attracting and holding to educational and research work the outstanding authorities in the several fields. The result has been to give the several institutions an individuality quite unknown among us.

The writer does not feel that the colleges can rest their case for industrial backing for their research programs on the needs of the colleges, or an assumed sense of obligation on the part of industry to see that the colleges obtain the men, money and facilities needed to do their best work. The industries recognize these obligations rather vaguely, and when confronted by the competing pleas of 100 to 150 institutions are justified in feeling rather helpless. The Babson report, however, speaks in the tongue which industry understands and to which it responds.

The work being done at Cincinnati in cooperation with the tanners' and the lithographers' national organizations, the power brake studies at Purdue in cooperation with the American Railway Association, the studies in warm air heating and ventilating at Illinois and the great project of the Portland Cement Association in association with Lewis Institute are worthy examples of adequately supported, nationally backed and effectively concentrated research programs, involving real collaboration between colleges and industries and leading to results of great significance and value.

The backwardness of research in our engineering colleges is probably due less to lack of money than to a shortage of competent research workers. Universities and colleges are the only agencies whose special purpose it is to train such men. The great industrial laboratories do much to further the education of their personnel, yet frankly admit their complete dependence on the universities for basic training. The engineering colleges are under a heavy burden of quantity production for the everyday needs of industry, and industry is in active competition for the more promising output of the colleges. The inducement to enter active employment at the end of the undergraduate period is very great. It is only rarely that men of creative ability have had the opportunity to test and appraise it at this stage. Between the solicitation of employing industries and the natural desire to try one's powers, we must expect most of the young men who might become productive researchers to pass into industry at this stage. The problem is to rediscover them and get them back into graduate schools after a reasonable period of orientation.

The opportunities in the field of engineering research must be kept more prominently before the student in his undergraduate years. This is the duty of both the engineering schools and the technical industries. Industry needs to recognize its own interest in selling research to a selected few young men, especially among its own employees. Industry needs to send selected men, of clearly indicated ability, back to the graduate schools for further preparation. Both the industries and the organized profession have a duty to make it possible for men of high creative abilities to remain in professorships without undue sacrifice of financial and professional opportunity. American schools of engineering enjoy an unparalleled freedom from outside regulation, but suffer from being left to fend for themselves in the face of conditions such as these. As a representative of the schools, the speaker yields to none in the frank criticism of their defects, but he wishes to assert that the engineering profession and the technical industries have received as much as they have deserved at the hands of the colleges, and even more. Without a heightened sense of responsibility on the part of these bodies and a more effective collaboration between them and the schools, there is little prospect that the defects will be mended.

W. E. WICKENDEN

THE DOCTOR OF PHILOSOPHY AND HIS BUSINESS[1]

IN the few minutes at my disposal let me offer some observations on two topics: (I) *The business of making a doctor,* and (II) *The doctor's business after he is made.*

I

And let us observe that the business of making doctors is one of the major industries of our country, a flourishing business. It is worth noticing that in our 576 colleges and universities the value of plant—that is, the value of buildings and grounds, of libraries, laboratories and material equipment—stands at over two billion dollars, and the annual budget for maintaining graduate education is well over $350,000,000. In these half a thousand institutions, over 150,000 graduate students are under discipline, and about 20,000 graduate degrees are awarded each year.

But this great industry is a young one in this country. Yale University, one of our oldest, conferred its first Ph.D. in 1861, and its list of awards at the present moment stands at 1,374.[2] Our own university, one of the youngest, has given, up to the close of the present academic year, 2,134 Ph.D degrees[3]—and all these since I first came as a student to the campus.

[1] Address at the annual luncheon of the Association of Doctors of Philosophy of the University of Chicago.

[2] *School and Society,* June 2, 1928, page 656.

[3] F. J. Gurney, Recorder, University of Chicago.

Not only is this business of making Ph.D.'s one of the major industries; it begins to look as though we were taking on the airs of mass production. But our task, though expressing itself in large figures, is not so simple as a major *commercial* industry. Our program can be stated as simply as the engineer states the business of making automobiles. In an automobile factory there must be: (*a*) an establishment of standards; (*b*) the machining of raw material into finished form, and (*c*) the grading of product.

But the engineer's problem is simple. The raw materials are uniform in quality. One bar of steel is like the next bar of steel. And though standards of accuracy read like fiction—the dimensions of shafts and bearings, for example, must be true within a tolerance of error of 1/4000 of an inch—there is no serious problem in obtaining uniformity of product.

Our business, the business of the staff, is likewise the establishment of standards and the grading of product—but our problem is not at all easy. Our material—men and women—is far from uniform. Individuals vary widely:

(*a*) In native ability. The Lord did not make them equal in any way. There are geniuses, and mediocrities. And the genius is usually a lopsided individual. He may be quite as marked in deficiencies as he is in excellences, when he is brought up before any set of standards.

(*b*) They may vary widely in preparation and training for the work we have to offer. Often their training has been haphazard and incomplete.

(*c*) They will vary in their response to discipline. Some are young and flexible, others have come late to their advanced work, and in some people the intellectual skeleton begins early to ossify.

And so, although we may establish ideal standards of accuracy, of competence and of refinement, it is hopeless to expect equality. We may not expect it in either rate of growth or in performance or in ultimate power.

To get this complicated raw product milled into a quality which may some day bear the label Ph.D. the seminar is established, and before the seminar the candidate brings a part of his prepared work to be criticized by the entire group. But good as this discipline may be, it is time consuming, and in a large group the individual candidate has a slender chance of having his own particular shortcomings brought home to him for elimination or amelioration. Individuals can not be ground effectively *en masse.* They require *individual* attention.

An eminent professor in Columbia University told me some years ago that he had twenty-seven candidates for the doctor's degree working under his sole supervision at one time. That is "mass production"