

THURSDAY EVENING SESSION

Kettering Award Address

On Some Conditions for Scientific Profundity in Industrial Research

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For about 20 years I have been interested in the question of how to establish in the United States a large number, perhaps several thousand, of new companies based in science. My dream was that each of these companies would conceive of a new field and would carry on from the basic scientific work in that field through research, development, engineering, production, aesthetic design, lively, honest advertising, and efficient distribution. Our life up until that time in our own

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technologically creative company had been so satisfying and happy that we wanted not only to continue in the same way ourselves, but also to induce others to create companies similar to ours. Nothing that has happened in the generation that has intervened makes me feel any less faith in the dream I then had, although the fact is that for one reason or another not nearly as many of these companies came into being as I would have hoped. Because I still believe in that dream, I want to talk tonight in some detail about the inventive experience in a company based in science.

Before I start on that detail, I must emphasize that the kind of company I believe in cannot come into being and cannot continue its existence except with the full support of the patent system. Since this Conference is dedicated to detailed discussion of understanding the needs of a healthy patent system, I shall make only one comment: namely, that except for the intricacy that has entered into interference procedures, the patent system as I have known it for the last 40 years is satisfactory in principle to support the kind of science-based industrial renaissance that I believe in. For this purpose, all that is required is an expansion of the Patent Office—an expansion of budget, facilities, and equipment, comparable to the expansion of demand being made on the Patent Office.

The specifications I now set for these ideal scientific companies are no different from the ones I set for myself in 1927—pick problems that are important and nearly impossible to solve, pick problems that are the result of sensing deep and possibly unarticulated human needs, pick problems that will draw on the diversity of human knowledge for their solution, and where that knowledge is inadequate, fill the gaps with basic scientific exploration—involve all the members of the organization in the sense of adventure and accomplishment, so that a large part of life's rewards would come from this involvement. My faith was that in the long run this kind of activity could be self-supporting rather soon, that it would inspire the desire of others, not participating directly, to share indirectly, by contributing sometimes advice, sometimes financial support, and sometimes a market, even though, to begin with, the market may have been created just to encourage us. Over this 40-year period, I have found that Americans bring instinctive optimism, generosity, and enthusiasm to the support of any effort that they believe is fundamentally creative. My only dis-

appointment then is that this instinct has not been tapped in the way I feel it can be to bring into being the thousands of new companies.

I want to review with you case histories from our own experience of the inventive process, in the hope that before the evening is over we may gain insight into how to encourage such companies as I seek.

As I review the nature of the creative drive in the inventive scientists that have been around me, as well as in myself, I find the first event is an urge to make a significant intellectual contribution that can be tangibly embodied in a product or process. The urge, as pure urge, precedes in a perfectly generalized way the specific contribution—so that the individual hunts for a *domain* in which to utilize the urge. The early stage need not be early in life, it can occur intermittently throughout life. The hunting process is fascinating to contemplate because during it there may be many abortive first approaches at the verbal level to fields which are then rejected as being either not significant enough or not feasible enough—and then, quite suddenly, a field will emerge conceptually so full blown in the creator's mind that the words can scarcely come from his mouth fast enough to describe the new field in its full implication and elaborateness.

This domain which neither he nor the world had known until some magic moment, now is for him so vividly real and well populated with ideas and structures that he will lead you around through it like a guide in a European city. Then it appears to him that all that is left to do is to parallel that intricate "reality" which came into being in his mind, with a corresponding reality in the world outside of his mind. Sometimes this process of creating the outside reality may take five years, sometimes five hours. For the creative person this process of establishing the correspondence between the outside reality and the one within his mind is a timeless undertaking, reminiscent of the relativistic trips through space in which people return to earth only a little older while the rest of mankind has aged.

Whether the process is the five-hour process or the five-year process it always turns out to be true that many subsidiary and supporting inventions and insights are required to go from the thing in the mind to the thing in the world. These subsidiary inventions are born of accurate analysis, patient research, broad experience, and total devotion to the perfection of the final outer reality. For this sequence of rather tedious virtues there is available no new series of *grand* excitements. Basic emotional energy must continue to flow from the initial perception of the field and from that first excitement.

Now I take you through these details of the genesis of inventions because it must be clear that this kind of timeless life can be lived only

in an appropriate environment, a different kind of environment from what we must establish for some of our important massive engineering undertakings, such as the moon probe, undertakings in which a date must be met at all costs, and in which individual profundity must be largely displaced by rapid-fire interaction between brilliant members of large groups. Since it is somewhat easier for the general public to understand and for the Government to manage this latter type of intellectual activity, we must be extremely careful to nurture and protect the former type with which tonight's discussion is chiefly concerned.

Now for examples: As for the generalized urge: Thirty-eight years later, I can still recall the full vividness of my own need at the age of 17 to do something scientifically significant and tangibly demonstrable. At the age in which each week seems like a year, I picked field after field before I decided that the great opportunity was polarized light.

Jumping ahead 17 years, I recall a sunny vacation day in Santa Fe, New Mexico, when my little daughter asked why she could not see at once the picture I had just taken of her. As I walked around that charming town I undertook the task of solving the puzzle she had set me. Within the hour, the camera, the film, and the physical chemistry became so clear to me that with a great sense of excitement I hurried over to the place where Donald Brown, our patent attorney (in Santa Fe by coincidence) was staying, to describe to him in great detail a dry camera which would give a picture immediately after exposure.

In my mind it was so nearly complete and so real that I spent several hours describing it, after which it was perhaps more real to him than even the ultimate reality. Only three years later, three years of the timeless intensive work referred to above, we gave to the Optical Society of America the full demonstration of the working system.

What is hard to convey, in anything short of a thick book, is the years of rich experience that were compressed into those three years. It was as if all that we had done in learning to make polarizers, the knowledge of plastics, and the properties of viscous liquids, the preparation of microscopic crystals smaller than the wavelength of light, the laminating of plastic sheets, living in the world of colloids in supersaturated solutions, had been a school and a preparation both for that first day in which I suddenly knew how to make a one-step dry photographic process and for the following three years in which we made the very vivid dream into a solid reality.

Once again we can see the significance of environment, of a corporate life whose managerial center was concerned with scientific ideas, a corporate life in which everyone participated in the mastery, day by

day, of the new technological problems that arose in our search for better polarizers and new ways of using them. The transfer from the field of polarized light to the field of photography was for us all a miraculous experience, as if we had entered a new country with a different language and different customs, only to find that we could speak the language at once and master the customs. In short, the kind of training we had given ourselves in the field of polarized light had endowed us with a competence we had not sought and did not know we had; namely, a competence to transfer what must be a common denominator in *all* honestly pursued research, from one field to an entirely different one.

I am inclined to think that only in a corporation, however small or large, in which individuals are expected to make the center of their life the intellectual life of the laboratory can this kind of transferable talent be built. This process must continue for year upon year and decade upon decade. I find men around me in our laboratory who have lived this way and who now seem more alert, creative, and productive than when they were 30 years younger. That creativity is tied to some youthful age is a myth that comes about, I believe, because for one reason or another men stop living this way perhaps because they are encouraged to think there is more dignity associated with tasks implying power over people than with tasks implying power over nature.

Remember that we are searching these case histories not for the purpose of intimate revelation, but to try to find out why more scientific companies do not survive. Whatever the other reasons may be, I think that a primary reason is that at just the time when a man's talent might be maturing, he is drawn off into a variety of so-called managerial activities. It is impossible for the long, long thoughts, the profound thoughts, the unconscious accumulation of insights, to come into being after these serious digressions into management. I am not saying that other good things do not come out of these diversions, but these other good things are not our subject. Actually here is an endless opportunity for use of managerial aptitude of every research man, *within the intimate domain of his own investigation*, and within that domain he may exercise his managerial aptitude without the stress and distractions he will necessarily find outside of the domain of his own scientific investigation.

I think the important and nearly impossible projects such as we set for our goal require prolonged periods of intensive concentration. Frequently, the problems can best be solved, perhaps solved *only* if the work is done in a relatively short time. In most of the worthwhile

problems, so many variables are involved that the human mind cannot keep them in order in the presence of interruptions. It is simultaneous mastery of a hundred interacting variables that is the glory of the kind of scientist we are talking about for our scientific companies.

When I started on the actual program of making the black-and-white film for our camera I set down the broad principles that would also apply to color. I invited Howard Rogers who had worked with me for many years in the field of polarized light to sit opposite me in the black-and-white laboratory and think about color. For several years he simply sat, and saying very little, assimilated the techniques we were using in black and white. Then one day he stood up and said "I'm ready to start now." So we built the color laboratory next to the black-and white laboratory and from then on until the time many years later when we released our color film, the program of matching the dream of the color process that was in our mind with the reality of the color process in the outside world never stopped. My point is that we created an environment in which a man was *expected* to sit and think for two years. May I suggest that there is a difference between that environment and the one which we tend to create when we think of national projects for massive engineering purposes.

You will note that the qualities that I am concerned about in corporate life are not related to bigness or smallness as such. There are small companies and small businesses that are not oriented towards thoughtfulness and profundity, and there are a few large corporations in which they are encouraged. But our universities do not train for patient and extended thought, and those few areas in Government which have provided thoughtful environments are in certain danger of being swamped by the great mass undertakings. The one *Governmental* device for protecting the profound thinker is the subject of your meetings this week—the patent system.

During the period ahead of us, many of us will be working to invent methods whereby the Government can catalyze the formation and growth of creative companies. We shall also be trying within the universities to generate men with competence for profound individuality. It would be most unfortunate if by the time we have succeeded with these undertakings the patent system is robbed of the power to perform its part of the new task.