ENTER THE GENERAL OF SCIENCE

An Amazing Picture of Modern Industry's Great Research Laboratories, Commanded by Scientists Of Note, With Regiments of Trained Men at Work on Problems Near and Far-Reaching

"The Professional Research Scientist of Today Is a Cool, Calculating Person."

By VALENTINE KARLYN

A FEW weeks ago Dr. W. D. Coolidge of the General Electric Company's research laboratories astounded the Franklin Institute with experiments that may mark the introduction of a new era in physical chemistry, industry and medicine. Under the unprecedented pressure of 350,000 volts, electrons were driven into the atmosphere through the delicately thin nickel window of a vacuum tube of his own invention. Exposed to these electrons, acetylene was reduced to a yellowish brown powder; castor oil was solidified; calcite, a pure form of marble, glowed for hours with a purplish light of its own; bacteria were killed instantly.

When the news of these experiments was published millions must have asked themselves: Who is this man Coolidge? Why drive electrons under tremendous pressure through the spaces between the atoms of a fine nickel membrane? What is the practical good?

Coolidge belongs to the latter-day school of professional research scientists—men hired by corporations to improve industrial methods and products by tearing matter into bits and then rearranging the bits in new ways, and to give us new fuels, new lamps, new means of communication. Corporations have organized research. They have made it self-perpetuating, continuous, orderly and systematic. Instead of waiting for the casual genius to appear and startle them with a new engine or a new explosive they rely on research to proceed step by step from something that is good to something that is better.

It is probable that corporation research scientists of the Coolidge type may completely supplant the picturesque, temperamental, romantic, heroic inventor who is responsible for what economists call the "industrial revolution," which followed the invention of the condensing steam engine by Watt and gave us the modern factory. Edison may be the last and the most dazzling of heroic inventors, unmatched and perhaps unmatchable in versatility and brilliancy of achievement.

Like the literary and musical genius, the imaginative inventor and scientist is regarded by those who pride themselves on their practical common sense as a little mad north northwest. Every madman must have his keeper. The heroic inventors of the past found their keepers in strong, domineering business men whose fortunes and mercantile ability made the fruition of spasmodic research possible. Without Boulton the great Watt would have abandoned the condensing steam engine time and time again; without Hubbard, his father-in-law, Bell would never have perfected the telephone. The mechanic or chemist who engages in research needs direction and control.

The exigencies of modern manufacturing have given research and invention a new economic importance. Discovering new compounds, improving processes whereby soaps, leather, drugs and the thousand and one necessities of life are manufactured, inventing new engines and machines—all this has become as much a function of modern business as selling goods in the markets of the world. The inventor or the chemist is no longer compelled to dream, work and starve in a garret. He is hired now to make discoveries almost to order. He may be less picturesque and eccentric than of old; he may be curbed; but he eats three meals a day and drives his automobile like the rest of us. His life is as uneventful as that of any clerk. The Samuel Smiles of the future who writes his biography will find it hard to make of him a hero, battling against the blind prejudice of an ignorant industrial world.

If we miss the fine frenzy with which men like Morse and Bell conducted their investigations in the past it is because the professional research scientist of today is a cool, calculating person. His is an academically trained mind. He knows exactly what he wants to do and how it is to be done. There is nothing of the showman in him. Goodyear used to clothe himself in india rubber from head to foot. Murdock, one of the pioneers of gas-lighting, wore wooden hats made with his own hands. Many of the pioneers of invention were embryonic Barnums, who basked in publicity like latter-day motion-picture idols. The hired research scientist indignantly spurns such flattering designations as "wonder-worker," "wizard," or "magician."

Even though he patents his discoveries on behalf of his corporation employer, he sometimes objects to being called an inventor; the term is too often associated with an unkempt, half-shabby dreamer who raves of perpetual motion. Yet the chemists and engineers in corporation laboratories are not blind to the drama that lies in converting some repulsive compound into a satisfactory insulator, in forcing vacuum tubes to perform new miracles in radio, in discovering some light-sensitive cell that will make it possible to broadcast motion pictures over half the planet. They simply object to being classed as human freaks.

Most of these hired research scientists are university trained physicists, engineers, chemists and metallurgists who take their work seriously, but who always maintain a strictly impersonal, objective attitude toward their achievements. The late Charles B. Scribner, who spent his life in the telephone laboratory of the Western Electric Company and who was granted hundreds of patents on telephone and speaking circuits, used to talk of his work in a detached way, as if he had been merely a conscious instrument in the hands of some mysterious, invisible, omniscient angel called Science. It was not he but Science which had somehow dispensed with the little crank which we once turned and which is still seen on the boxes of country telephones and without which "Central" cannot be signaled.

We have two types of industrial research in Europe and America. The one is concerned only with the attainment of commercial results; the other, more idealistic with the advancement of science, even though laboratory buildings, equipment and salaries are paid by corporations that scrutinize balance sheets with meticulous care and never spend a dollar without the prospect of earning five more. Paradoxical as it may seem, the *(Continued on Page 22)*

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untrammeled laboratory that works in the idealistic spirit of a university, with no direct industrial end in view, makes more startling, and, in the end, more practical discoveries. The "practical" industrial laboratory, conducted for the sole purpose of obtaining immediate commercial results, enriches its corporation founders with millions; but the idealistic laboratory, which delves in pure science, has earned tens of millions.

Thus the German coal-tar industry would never have given the world ten thousand synthetic perfumes, drugs, antiseptics, explosives and dyes without research in pure, organic chemistry, and the greatest of American electrical manufacturing companies would never have reduced the cost of light to one-third of what it was fifteen years ago unless it had given its research scientists a free hand in studying the chemistry and physics of reactions that occur in a vacuum. Coolidge's success in forcing electrons out of an X-ray tube into the atmosphere and performing astonishing experiments with them is due to this idealistic policy. Ten years hence the Coolidge method of harnessing electrons will probably be applied in factories to produce compounds of which we are not yet aware, and unimaginable industries will be founded.

Whatever its type may be, the laboratory of a great corporation is conducted as punctiliously as if it were a factory or a selling office. At the head of it stands a man who is not only a scientist of national, even world-wide, reputation, but a man who possesses the qualifications of leadership.

Research is systematized and conducted day in and day out in such a laboratory. Chemists, physicists, engineers and metallurgists keep regular office hours and draw regular salaries. At the top of the staff, next to the director, stand from three to twelve doctors of philosophy, men who may have once filled unremunerative professorial positions in universities. Below these we find recent graduates from universities eager to learn what corporation research means, mechanics, instrument makers, glass-blowers, artisans representing a dozen or more handicrafts—privates in this scientific regiment.

How the Task Is Laid Out

The task to be performed is assigned, but not quite as definitely as if it were brick-laying or typewriting. There are periodic conferences in which the director and the top men discuss a problem which, if solved, means either the saving or the making of millions in the factory. The problem may be suggested by the factory managers or the corporation's officers, or it may originate in the laboratory itself.

Usually the suggestions that come from the offices of the corporation or the factory are of minor technical importance. A water-proof paste is wanted for cartons. The lubricant used under heavy pressure and at high temperature in some machines is not satisfactory. Will the laboratory please supply a heavy grease that is better? The glass used in connection with a certain metal cracks because the metal and the glass do not expand at the same rate when heated. Can the laboratory specify a metal which will have the same co-efficient of expansion as glass?

These are regarded as simple questions, although they can be definitely answered only after months of experimenting. Far more profound and far-reaching are the problems that the members of the research staff themselves propound.

They never work blindly—these hired inventors and discoverers, these modern revolutionists of industry. First, the "literature" of the subject is studied—patents, books and technical articles in French, German and English, some of them published two centuries ago. The researcher saturates himself in his subject. He begins where his predecessors left off. Perhaps he may repeat a few of the more promising experiments recorded in old patents, books and articles, to verify the conclusions reached or to ascertain if some tremendous trifle has been overlooked; for in chemistry and engineering trifles are always tremendous, spelling as they sometimes do the difference between failure and success.

But not yet is the researcher ready to marshal the laboratory's resources. He works at his problem mathematically or with formulas and graphs. He wastes no time on experiments which are hopeless because they cannot possibly satisfy one or more of a hundred scientific "laws" and well-established principles.

Here he differs from the Arkwrights, Stephensons, McCormicks and Morses of old. They had to build models in the beginning, often a score before one was conceived that was worth development. He begins with something that he knows to be attainable, although it may not be the product that will ultimately be described in a patent assigned to the corporation. But he does as little guessing, as little empirical work as he can. Dr. Irving Langmuir of the General Electric Company's research laboratory worked out the modern gas-filled incandescent lamp on paper after he had discovered the relation of heat-radiation to wire diameters and why bulbs blackened. He predicted that his unborn gas-filled lamp would consume a half watt of energy for each candle-power. It did—the very first made in the laboratory under his direction.

Not until he has definitely decided what course is most likely to lead to the desired result is the researcher ready to begin actual experiment. Then he becomes a general of science. He summons instrument-makers, artisans, mechanics and directs them to make the apparatus that he needs, precisely indicating by drawings and written descriptions the material to be used, dimensions, and the character of the workmanship expected. In conducting the actual experiments he usually has lesser lights to help him. It is reported that at one time Dr. Coolidge commanded the services of twenty-two assistants in solving the stupendously difficult problem of making brittle tungsten so ductile that it can be drawn into a filament.

When, after months and even years of patient experimenting and testing, an industrial scientist at last reports that he has succeeded in producing a new lamp, a new synthetic dye, a new alloy, a new tube for radio receivers, and makes his report, the task is far from being completed. The research laboratory is usually not concerned with designing factory machinery or devising the processes whereby a new device can be made. That is left to special development laboratories managed by directors of their own. Here the engineer reigns supreme.

Without research and development laboratories of the type described there would be no radio broadcasting; no photographic industry paying dividends greater than those of all German coal-tar works combined; no corn-products industry to utilize corn which might be used as fuel for lack of a market; no meat-packing industry to make money out of the things the old-time butcher threw away; no telephone industry to link New York with San Francisco; not one of the electrochemical products now made by utilizing great water-power.

Research either creates something new or enhances values. A standing pine tree is worth $10 a ton. Fell it and strip it and its value leaps to $15 a ton. Apply research, find out how it can be converted into paper and it is worth $55 a ton as pulp. Take the pulp and discover in the laboratory how it can be transformed into artificial silk and the price soars to $5,500 a ton. Clearly, research pays.

Research need not be conducted on an epic scale to yield rich manufacturing returns. Chemists and engineers who have their own laboratories can be hired like doctors and lawyers. One office building in New York is entirely given over to chemists and their laboratories—practitioners of industrial research retained by small manufacturers who know that as little as $2,000 a year spent now in research for purely commercial ends may net tens of thousands five years hence.

Following the example set by the Mellon Institute of the University of Pittsburgh, several of our universities have established departments of industrial research to which the small manufacturer may also resort when he finds it hard to keep pace with the gigantic strides made by the large corporations. A few thousand dollars placed at the disposal of these universities, the signing of a contract whereby a small royalty is paid to the post-graduate student who may successfully solve a set problem—nothing more is required to keep any small manufacturer in step with the research procession. Cosmetics, hair dyes, glue making, oil-cracking, papermaking, automobile engines, breadmaking, laundering, glass-making, every conceivable product and manufacturing activity has been studied by these comparatively new university departments of industrial research. Rarely is a downright failure reported.

Cooperative Research

When the demands on research become financially too burdensome, the small manufacturer by the mere act of joining an association of competitors enjoys the profits of research. Canners, paint makers, laundrymen and cement manufacturers have thus joined forces and established association research laboratories in which some of the finest bacteriological and chemical studies of our time have been made. There are a score of these association laboratories. They have made preserved foods, bread, paint and dozens of luxuries and necessities better and cheaper. The discoveries become the common property of the contributory members of the association; for it is better to find out from an association laboratory why your can of tomatoes bulges on a grocer's shelf, why your bottled water becomes cloudy and unpalatable, than to go to the wall because your goods are unsalable and your reputation is lost.

When large-scale industrial research is well under way it becomes possible for its sponsors to prepare for the future. It is rarely that a momentous invention or discovery is introduced in less than five years after experimenting begins. Often enough ten or fifteen years roll by before a commercial result is attained. A distinguished mechanical engineer, W. L. R. Emmett, in the employ of a manufacturer of central station machinery, has been working for more than twelve years on a method of generating electricity with mercury vapor instead of steam as the motive agent of turbines, and twelve more may well elapse before power houses can apply his revolutionary principles.

All of the larger electrical manufacturing companies are already prepared for superpower, by which term they mean the pooling of electric energy so that a surplus in New York may be drawn upon to make up a deficiency in Washington. Go to one of three directors of as many German research laboratories and they will tell you that synthetic rubber will probably compete with plantation rubber by 1940, but not supplant it; that New York, Berlin, Paris, London and Chicago will have noiseless streets paved with rubber and that we will use varieties of rubber unknown in nature for hundreds of purposes in place of wood, leather, cloth and metal.