belongs the credit of conceiving, and showing how mortal man may speak with his living voice directly to all the generations that follow after him. Could we to-day but hear Socrates and Marcus Aurelius and Shakespeare and Newton and Franklin and Goethe and Faraday and Maxwell, as our children and our children's children through the long ages will be able to hear their counter-parts of to-day and of all the times yet to come, would we not build another Promethean legend around that deed akin to that of stealing fire from heaven and bringing it down to men. That man has lived and worked and walked on earth with us in our generation. Thomas A. Edison is his name.

EDISON'S LABORATORY IN WAR TIME

By Dr. KARL T. COMPTON

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DR. JEWETT and Dr. Millikan have discussed the importance to science of some of Mr. Edison's inventions and investigations. My own talk will, like Mr. Edgar's, be based on a personal contact with Mr. Edison and his laboratory, and through it I wish to give additional details to the picture of Edison as a workman and as a scientist.

Immediately following the declaration of war in 1917 Mr. Edison telephoned President Hibben, of Princeton, requesting him to send to his laboratory four scientists as volunteer war workers. I went with three of my colleagues from the department of physics and remained for the months required to bring to a conclusion the problem which was set for me by Mr. Edison.

All through the war the newspapers published frequent stories of Edison's war activities and of the secrecy in which they were carried out. One story which I remember described experiments carried on in the dead of night on the top of a mountain with armed guards posted all around the base. Whether these stories are true or not I do not know, but I do know that Edison's research laboratory was actively at work and that contact with this work gave me a vivid picture of Edison and his methods.

Immediately upon meeting Mr. Edison and barely taking time to say "how do you do," he took out his pencil and began to describe a problem which had been put up to him by the Naval Consulting Board—the problem of increasing the efficiency of the driving mechanism of a torpedo so that a larger amount of explosive could be stored in it without changing its range or size. He gave me a very brief history of the development of the present torpedo, told me the conditions which an improved torpedo would have to satisfy, and told me to come back to see him when I had a solution.

In about three weeks I reported to him that I had found three fuels which seemed to offer possibilities. He disposed of these solutions in three sentences: "Fuel A can only be obtained in Germany. Fuel B has been tried but discarded because of the danger of explosions. Fuel C, which included wood alcohol, is no good because the sailors drink the d— stuff."

So I went back for another couple of weeks and returned with a fourth solution. Mr. Edison took the papers, looked over the calculations, muttering the while to himself, and then said, "When I don't understand work like this I get two men to work at it independently. If they agree, maybe it is all right; if they don't agree, I get a third man. Go up into room — and see whether you agree with a young fellow from Columbia University whom I put to work on the same problem."

On interviewing this Columbia scientist I found that we agreed entirely as to method but disagreed radically as to conclusions. Whereas I had found very few fuels possibly superior to those which the Navy was using, he had found that almost every fuel was superior. On looking over his work, however, I found that he had based all calculations on a formula for alcohol, $C_{12}\ H_{22}\ O_{11}$, which is sugar. In other words, he had been actually finding out what fuels would be better than sugar for driving the Navy's torpedoes. When I asked him where in the world he had got that formula for alcohol he said, "You see, I am a mathematician and not a chemist so I went to the library," and with that he showed me an ancient book on chemistry, in which $C_{12}\ H_{22}\ O_{11}$ was actually given as the formula for alcohol.

Following this conference, Mr. Edison arranged for me a visit to one of the naval torpedo stations, where the calculations were checked by the torpedo engineer and the work was left in the hands of the Navy, with what results I do not know.

A second investigation illustrated Mr. Edison's great fertility and imagination. There had been numerous demands for the development of a supersensitive microphone for detecting enemy operations by night or under the ground or beneath the sea. According to Mr. Edison the ordinary carbon granule microphone had too high a resistance, and he wanted to try metal granules, "But," he said, "metal granules are too blamed sluggish. We must make them lighter." He so devised this scheme: First he got a large supply of hog's bristles from a local brush factory; then he plated these hog bristles with a great variety of different metals. Some of them were plated by the electrolytic process, which he used in manufacturing his phonograph records; others were plated by cathode sputtering in a vacuum; and still others by the condensation of evaporated metals. When each of these hog bristles had plated on to it a thin coat of metal, the bristles were cut up into tiny lengths, each about a hundredth of an inch long, by a microtome such as is used in cutting specimens for microscope slides. These tiny little cylinders were then placed in a bath of caustic potash, "the stuff men dissolved their murdered wives in," said Mr. Edison, which dissolved out the hog bristle and left a tiny hollow cylinder of metal, shaped like a napkin ring, and these were the metal granules which were used in place of carbon for the experimental microphones. How well they worked I do not know, since I did not see the conclusions of the test. My guess would be that they did not work as well as carbon, since scientists think that there is a peculiarity in the structure of carbon which makes it particularly effective for microphonic purposes. It was one of Mr. Edison's characteristics, however, that he would not let his own, or any one else's preconceived ideas stand in the way of making a test. This practice certainly led to many futile experiments, but it is equally true that it led to some successful discoveries which caused the scientists to revise their earlier ideas. Edison was not ignorant of what others had done, even though he often appeared to pay little attention to it. A great reader, frequently, before starting, he read everything which had been published on the subject.

Typical of another method of Mr. Edison's work were experiments on flame throwers and on submarine periscopes. The flame thrower was desired to throw a stream of liquid as far as possible. In order to get the right design of nozzle Mr. Edison instructed one of his helpers to build in his shop a whole series of nozzles with every gradation of angle, length and shape within wide limits, and to pick out the one which threw the stream the farthest.

In the case of the submarine periscope the problem was to prevent the deposit from evaporated salt water spray from rendering the periscope mirror non-reflecting. To prevent this several things were tried, one being to bathe the mirror periodically with materials of very low surface tension, which would prevent the accumulation of water in drops. For this purpose a whole series of liquids was tried and the most satisfactory one selected.

These last two war problems illustrate the method of continual search and trial which underlay much of Edison's work. Notable examples are found in his selection of elements for the Edison storage battery and in his preparation of more than 10,000 double chemical salts in the endeavor to find the most satisfactory fluorescent screen for use with x-rays.

It is a mistake, however, to think that all Edison's work was carried on by this search and trial method. Back of everything which he did or tried there was always an idea. The starting point was always the need of accomplishing some purpose, the second stage seemed to be the suggestion of various ways of accomplishing that purpose, and the final stage consisted in trying out these suggested solutions in as thorough and systematic a manner as possible in order to find the best.

Edison's success lay, I believe, equally in his handling of all three of these stages. He was uncommonly alert to opportunities for supplying a need or presenting an improvement. He was uncommonly ingenious in figuring out ways of designing apparatus to do what he wanted it to do, and he was one of the most patient and persevering men who ever lived in carrying through his ideas to the last stage of comprehensive test.

There are some who think that the day of the inventor of Mr. Edison's type has passed because of the continually greater and greater degree of specialization and scientific background which is demanded. Whether or not this is true, it is certainly true that the talents which Mr. Edison possessed are talents which will always find their outlet in creative service.

Quoting from the inscription under an Edison portrait that appeared in the *General Electric Review*:

He had the boyish fancy to create,
Invent, devise, design, and fabricate.
Sanguine and ardent, bold and fertile too,
He dreamt. Then worked—and made his dreams come true.

J. R. H.

OBITUARY

SAMUEL MATHER

SAMUEL MATHER died in Cleveland, on October 18, 1931, at the age of eighty years. Through this long span of life, Mr. Mather had devoted a large part of his energies and of his fortune to bettering the condition of mankind. In this he blended warm-hearted