the science of bacteriology, and, in particular, of the germ theory of disease, for a century and a half.

The plague tracts of the fourteenth century recognized the importance of contagion in the spread of epidemic disease as clearly as we recognize it to-day; and in the sixteenth century, Fracastorius developed a complete and closely reasoned theory of contagion by direct contact, through the air and by fomites which can scarcely be improved upon in 1939. The contagious element was, however, conceived in chemical rather than biological terms. Although Fracastorius wrote of "germs" or "seminaria," it is clear from the context that the term was used only as we might speak of "the germ of an idea" and not as implying living organisms.

This gap in epidemiological thinking was, however, filled in the seventeenth century. Athanasius Kircher, in his "Scrutinium Pestis" in 1658, first clearly advanced in definite and challenging terms the theory that communicable disease was due to *"contagia animata"* to minute living "worms"; and he backed up his contention by actual observation of such worms in decomposing organic matter and, perhaps, in the tissues of plague patients themselves. With the microscopes at his disposal he did not, of course, see bacteria; but his championship of the conception of living germs as the cause of disease is a landmark in the history of epidemiology.

Kircher held that the germs he postulated were spontaneously generated in decomposing organic matter. Ten years later, in 1668, Francesco Redi, in his "Experiments on the Generation of Insects," corrected this error and demonstrated experimentally that—for the maggots of insects at least—spontaneous generation did not occur, but that, when living matter was apparently produced from dead matter, the seeds of life must be introduced from outside.

Within one more decade, in 1676, Antony van Leeuwenhoek of Delft actually discovered the bacteria with his powerful magnifying glasses and described them in his epoch-making letter to the Royal Society of London—the letter which Cohen has reproduced and published for our society in full. Thus, by 1700, there was available the *"contagium animatum"* concept of Kircher, the demonstration of biogenesis by Redi and the discovery of the bacteria by Leeuwenhoek. If an open-minded and imaginative observer had put the work of these three pioneers together, the germ theory of disease could have been developed in the seventeenth century instead of the nineteenth.

Unfortunately, there was no leader in seventeenth century medicine capable of accomplishing such a synthesis. On the contrary, Thomas Sydenham, its outstanding figure, ignored the factor of contagion almost completely and based his whole theory of epidemiology on the epidemic constitution of the atmosphere, an occult property beyond the power of observation, let alone measurement; hence, nearly two centuries of sterile philosophizing and controversy between miasmatists and contagionists—which was only terminated by the experimental methods of Louis Pasteur.

The bacteriologist of 1940 will not need warning against the errors of Sydenham's approach. We have learned the lesson that the assumption of a force beyond the scope of actual observation leads to metaphysics and not to science. There is another lesson from this seventeenth century situation which has, I believe, a fundamental message for us. That lesson is the importance of openmindedness and imagination in visualizing the importance of new observational and experimental data in fields allied to—but somewhat removed from—our own. There is a similar lesson in more recent experience. It is astounding to me to realize that I, with all the bacteriologists of my generation, had under my nose each day plates containing rough and smooth colonies, and for twenty years we ignored them. Even the scientist too often sees with his mind and not with his eyes. Custom and inertia blind him to the light that is ready to pour in. If you young men are to carry on the torch of bacteriology, keep your minds free from hampering pre-conceptions and open to new truth. I once had in my laboratory a text on the wall which read, "The experiment which succeeds teaches us nothing." If things come out as we have anticipated, we are only craftsmen perfecting an edifice already erected by others. The exception to the rule, the unexpected result, the novel observation in some other science which can be related to our own—these are the materials by which the new cathedrals of science are built. If you who are beginning your careers have courage and imagination, curbed always with the bit of experimental verification, the second forty years of American bacteriology will be more glorious than the first.

PRESENTATION OF THE GOLD MEDAL OF THE AMERICAN INSTITUTE OF THE CITY OF NEW YORK

A MODERN PIONEER

I AM grateful for this opportunity to join with The American Institute of the City of New York in honoring one of our country's great pioneers, Dr. Frank Conrad.

America's early pioneers were men and women who

had the vision to see, in the unknown wilderness of this continent, the secret of a better life. They had the faith and the courage to go and find it.

To-day, the frontiers of geography have almost vanished. The unexplored regions of the globe are few and far between.

But expanding civilization still calls—more loudly than ever before—for the pioneering spirit. To-day's objectives differ from those of a century ago, but they require no less the pioneering qualities of vision, faith and courage.

The modern pioneer explores, not the surface of seas and continents, but the unknown spaces that lie beyond the present frontiers of human knowledge. He grapples with the secret forces of the universe. He blazes a trail of experiment and invention into the boundless wilderness of our ignorance, and converts it bit by bit into a fertile land of useful knowledge and service.

Such a pioneer is Dr. Frank Conrad, to whom we are glad to pay our respects this evening.

Shortly after the end of the World War, Dr. Conrad, who had been in charge of earlier research in radiotelephony for the Westinghouse Electric and Manufacturing Company at Pittsburgh, decided to resume his work in this field. He had two experimental stations—one in the plant and one in his home four or five miles away. That was an ideal set-up for a modern pioneer: he could work all day at one place, and all night at the other.

In April, 1920, Dr. Conrad began sending out experimental broadcasts. He would talk into the microphone and then, for a rest, would play phonograph records. His broadcasts began to attract attention around Pittsburgh, and stimulated the sale of radio parts to home-set builders; so much so, in fact, that business executives of his company authorized him to build a new radio-telephone transmitter, which was completed in the fall of 1920.

The broadcast of the Harding-Cox election returns over the Westinghouse Station KDKA in Pittsburgh made history. That event, on November 2, 1920, is now universally regarded as the birth of public radio broadcasting. In a short time, other broadcasting stations sprang up in all sections of the country. A new and powerful medium for the instantaneous dissemination of culture, entertainment, information and news to all people was thus born, and a new American industry was launched.

Although it was the 1920 election broadcast which chiefly made the name of Frank Conrad known to the public, he has made many contributions of basic importance to radio. Time does not permit me to mention them all. I am told that he has more than 140 patents to his credit, and they are by no means confined to radio.

His inventions relate to electrical meters and instruments, dynamo-electric machines, vehicle lighting circuits, mercury arc current-rectifiers and power distribution systems. They touch the entire field of radio in the realm of both long and short waves. He has also made important inventions relating to motion picture apparatus.

In the early days, Dr. Conrad did not share the viewpoint of some other engineers, who looked on radio as something strange and apart from other electrical phenomena. He refused to regard radio as a mystery. To him it was just an interesting new kind of problem connected with alternating currents. Like all great pioneers, Dr. Conrad possesses a lively bump of curiosity and an unwillingness to take things for granted.

In the early twenties, an associate of Dr. Conrad returned from a radio conference in Washington, and told how the amateur operators of that day objected to being forced down into the "sewer waves." "What are the sewer waves?" asked Dr. Conrad. He was told that the waves shorter than 200 meters were regarded as useless, and "down in the sewer." "What is wrong with them?" he asked. He was given reasons why they wouldn't work, and, characteristically, he simply refused to accept the explanation. He convinced his associates that a theory based upon spark transmitters, then in general use, did not necessarily hold true with regard to vacuum tube transmitters, whose development later made the older system of spark transmission obsolete.

That early associate of Dr. Conrad is also present with us this evening. He is Charles W. Horn, a former Westinghouse employee and now an official of the National Broadcasting Company. Later in the evening he will demonstrate to those present in this room what the "sewer waves" are doing for us in the year 1940.

Practically all point-to-point radio communication and all international broadcasting are now conducted in this short-wave area of the radio spectrum. The development of short waves for practical use led radio research men to probe deeper and deeper into the mysteries of radio-wave propagation in the higher frequencies. Many new developments, the most outstanding of which are radio facsimile and electronic television, have come out of these studies. Many more are yet to come.

We occasionally hear it said that modern invention has gone too far, that it has created economic and social problems—especially unemployment—and that these can not be solved unless research is stopped. None of us wants to see men of Dr. Conrad's type plowed under, so this occasion is surely an appropriate one on which to condemn this defeatist attitude toward invention.

If American industrial history proves anything, it proves that invention has created many more new jobs than have been taken away by technological improvements or labor-saving devices.

Radio, for example, is purely a child of invention. To-day the radio industry, which practically did not exist twenty years ago, provides direct employment for 400,000 persons. Their annual wages reach an estimated total of half a billion dollars. Indirectly, radio provides employment for many thousands more.

Radio has now added sight to the service of sound. Television is here. It might more accurately be called "radiovision." It promises to add a brilliant new chapter to the annals of American economic development, and ultimately to provide new channels of employment for workmen and white-collar men, artists and writers, technicians and scientists.

The United States was created by pioneers. It was made great by other pioneers. As long as the pioneering spirit lives, America will go forward.

Dr. Frank Conrad is an illustrious example of this pioneering spirit. Difficult problems, that were a stop signal to others, were to him only a green light. Of him it may truly be said, that:

> He didn't know it couldn't be done,
> so he did it.

Mr. President, I have the great privilege to present to you, for the high honor of the Gold Medal of the American Institute of the City of New York, one of America's true pioneers; a man respected and admired throughout the electrical and radio industries, a benefactor of humanity and my friend—Dr. Frank Conrad.

DAVID SARNOFF,
President of the Radio Corporation of America

THE STORY OF SHORT WAVES

MR. CHAIRMAN and ladies and gentlemen, I deeply appreciate the honor extended by the American Institute of the City of New York in awarding me the institute's medal. I am particularly gratified that the award was determined in part by work in the development of radio broadcasting.

Radio broadcasting may justly be classed among the developments which have done most to produce our present civilization. The important ones, as I see them and in the order in which they came into the world, are printing, the railroad, the telephone, the automobile and the radio. Each of these developments has moulded the lives of people and changed the destinies of nations by facilitating the interchange of goods or ideas.

In the forefront of these agencies for the extension of civilized thought and action is radio broadcasting, a development so recent that even to-day it is no older than the average college sophomore. Ultimately, it should be a mighty weapon for peace, but paradoxically, it was literally born of the last World War. One of the factors which made it possible for science to have ready nearly all the tools required for this entirely new art was that war.

Before the struggle began, radio was considered as a possible rival of the telephone or telegraph wire, and its apparent field of greatest use was in communication from ship-to-shore, vessel to vessel or with isolated spots. The desirability of communication between ships for even limited distances served as an impetus to the development of devices which would thus enable a ship in distress to call for help. The apparatus as developed before the war period effectively served this purpose, although it would not make possible the use to which radio is put to-day. The military necessities of war time not only furnished the incentive for a further development of radio, but, what was even more important, it furnished the necessary financial support of this work.

At the close of the war, we found ourselves in possession of the radio products of many research agencies but with no apparent use to which to put these products. The tools were there, but so far as the world could see, there was no new work for them to perform. In my own case it was undoubtedly the natural fascination of working with a new tool that induced me to continue my research and experimentation.

To-day we all know that radio has come far and fast since those war days. Broadcasting—and particularly short-wave broadcasting—is developing so rapidly that it is hardly safe to make predictions as to its future, lest the prophecies become matter-of-fact realities before they appear in print.

However, with a background of more than 20 years' relationship with radio, I am convinced that if radio broadcasting is to continue to expand, and I have no doubt that it is, then the short wave-lengths offer the only road to that expansion. Two developments in the use of short-wave bands for a wider dissemination of entertainment and culture appear to be imminent at this time: first, a network of short-wave broadcasting stations; second, within a matter of ever-shortening time the ultra-short wave bands will be carrying television.

These forecasts are conservative, even "tame," compared with a few made by the late H. P. Davis, vice-president of the Westinghouse Electric and Manufacturing Company, a few months after the first scheduled commercial broadcast was made over station KDKA in 1920. Mr. Davis said: