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ARMY INDUSTRIAL COLLEGE.  
Washington, D.C.

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RADIO IN RELATION TO THE PROBLEMS OF  
NATIONAL DEFENSE.

ADDRESS

By

LIEUT. COL. DAVID SARNOFF, S.O.R.C.

Before

THE ARMY INDUSTRIAL COLLEGE.

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February 20, 1926.

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It is not necessary, before a body of officers of the Army and Navy of today, to speak of the importance of communications; it is not necessary to argue about the importance of communications. This was not true fifteen years ago. In those days very little consideration was given to the subject of communications in the formation of war plans, but that situation has been changed.

To those officers who were unfortunate enough to be located in the United States during the war, it is apparent also that there is a great need of communication in the home country during a period of war. In the production of munitions great confusion and delay occurs, if the country is not provided with an ideal system of communications, so we can readily see that adequate communication is not only necessary in tactical operations but in industrial operations at home.

Just before the war there was a very remarkable situation developed in Radio industry in this country. Radio, as you know, is today very rapidly becoming one of the most important means of communication, it is a factor in the lives of our people, not only in the life of the business man, the social man, but the farmer living in an isolated section.

Before the World War a very unusual condition obtained due to a number of conditions. Let me illustrate this. Suppose the Army or Navy wished to get out a new type of radio set. They could do that only by surmounting a large number of difficulties. This was brought about by a confusing state of patent licenses, and other business conditions. It was apparent to business men and apparent to men in the Government that something ought to be done to relieve this situation, as they saw the need for the formation of some organization which would get together these loose ends and prevent the radio industry from being paralyzed.

That situation was met by the organization of a Company now known to us as the Radio Corporation of America. That is one of great importance to the United States in the field of communications.

I wish we had on the wall here a chart showing the various offices that could be filled by a man starting in the radio industry. The different offices that a man could hold, beginning at the very bottom, the different steps that he would go through in starting at the bottom and reaching the top. If you had a man who had occupied

one-third of those offices, he would be a man very well qualified to speak to you today on the subject of radio, if you had a man filling one-half of those positions, he would be better. I know a man who started in in 1906 at the very bottom and who, in eighteen years, has filled every position except one. That man, today, is recognized by the Western Union, the Postan, Cablegram Company and the Army and Navy as an authority.

It is a great pleasure to introduce him to you this morning - Gentlemen, Colonel David Sarnoff, of the Signal Corps Reserve.

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RADIO IN RELATION TO THE PROBLEMS OF

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General Seltzman and Gentlemen

It is a great privilege to be permitted to appear before you this morning for the discussion of so important a subject as the relation of radio to the problems of national defense. I confess at the outset to a greater degree of hesitancy than usual, for I know that I am talking to a highly professional audience, many members of which have devoted years of study to problems which I am only able to sketch briefly from my angle of experience in communications.

General Seltzman has so clearly set forth the importance of communications in national emergency that I shall not depart from the text which his remarks suggest. I am particularly glad that among my audience this morning there are officers of the Navy Department who have had so much to do with the formation of the Radio Corporation of America, and especially Commander Hooper. Those who recall the events which resulted in the formation of an American-owned and controlled system of wireless communications in the United States will remember the part played by Commander Hooper, as head of the Radio Division in the Bureau of Steam Engineering of the Navy Department. Commander Hooper not only foresaw the great development of wireless communications but the necessity of guarding this new agency from alien ownership or control, in view of the part which it was destined to play as an arm of the national defense.

Although much progress had been made and much money had been spent in the development of a trans-oceanic wireless communications system, there did not exist prior to the World War adequate facilities for a regular and uninterrupted trans-Atlantic radio service. The Alexanderson alternator, America's great contribution to long distance wireless development, made reliable communication possible. To have permitted it to fall into the control of foreign hands would have robbed the United States of the leadership which it now enjoys in world-wide wireless. The country owes a debt of gratitude to the foresightedness of its Government officers who supplied the impetus for the creation of an American system of radio communication.

Radio, like Gaul, is divided into three parts -- Marine, Trans-oceanic, and the latest field, Broadcasting. Each has a distinct mission.

It was natural, perhaps, that radio should find its first expression on the seas, because no other means of communication could bridge the distance from ship to ship or ship to shore. The history of radio on the ocean is generally known. My own experience dates back eighteen or nineteen years, when I was an operator on ships crossing the Atlantic. Those were the days of the ten-inch spark coil, of the old coherer and the crystal detector, when communication range was limited to a distance between fifty and one hundred miles from ship to ship or to shore stations.

Today, of course, marine communication is conducted with the reliability and assurance of any other form of established communication. The Radio Corporation of America maintains a system of coastal stations, inter-connected by wire and directed from our main office in New York. Today a message can reach any ship equipped with radio, no matter what part of the seven seas the ship may be navigated.

The next development is clearly forecast by recent experiments. Radio telephonic conversation between ship and ship and ship to shore already has been achieved, and two-way conversations by wireless across the Atlantic Ocean has been demonstrated successfully.

In the matter of trans-oceanic communication, the development of the past few years has been upon a scale that has exceeded the greatest expectations. From Radio Central, the main transmitting station of the Radio Corporation, on the north shore of Long Island, we are in direct communication through the air with Great Britain, France, Germany, Sweden, Holland, Italy and Poland. From the Pacific Coast, wireless circuits radiate between the United States and the Hawaiian Islands as well as Japan, and Java in the Dutch East Indies.

The competitive system of trans-oceanic communications established by radio has resulted in the marked lowering of rates; we now manufacture our own apparatus and equipment for wireless service, whereas prior to the war such apparatus had to be imported from abroad; we are in fact installing American wireless plants in European countries -- there are American stations in England, Sweden and Poland, and American-made receiving equipment is used in practically every trans-oceanic radio station in Europe. Radio has proved a harbinger of better trade and economic relations, for just as it is true that commerce follows the flag, so it is true that communication must precede trade.

I have spoken of existing services. There are projected services which will give even more marked leadership to the United States as the focal point of radio communication for the entire world. The Radio Corporation of America through its subsidiary, the Federal Telegraph Company of Delaware, has been planning for a service to China, a development which would cost many millions of dollars, but which is in deadlock now because of a conflict at the moment between various foreign organizations having communication interests in China. Although there is daily contact by radio between the United States and South America, through our New York - Buenos Aires circuit, communication with Rio de Janeiro awaits the completion of a station now under construction and which will be ready in the very near future. We are also projecting operations in the Philippine Islands, and I do not think many years will pass before we shall be in direct radio communication with every important country in the world.

In the field of radio broadcasting, the progress both of the art and the industry is now a matter of record. The following figures will indicate the proportions which the industry has grown.

RADIO BROADCASTING INDUSTRY.  
(Figures as of Dec. 31, 1925)

STATISTICAL STUDY MADE BY RESEARCH BUREAU  
Radio Corporation of America.

General Statistics.

Total Homes in the United States .. .. .	26 000 000	
Homes having phonographs . . . . .	10 500,000	44.4%
Homes having automobiles ... .. .	15,000,000	57.7%
Telephones (home and business) .. .. .	16,900,000	65%
Homes having radio receivers .. .. .	5,000,000	19.2%
Homes not having radio receivers .. .. .	21 000,000	80.8%

Radio Figures.

Broadcasting Stations in the U. S. ....	566
Broadcasting Stations throughout the world.	922
U.S. vessels equipped with radio telegraphy	1,900
Foreign vessels equipped with radio telegraphy... .	9,000
Licensed broadcast receivers in England ...	2,000,000
Broadcasting Stations in United Kingdom ...	21
Estimated Broadcast Listeners in U.S. . . .	20,000,000
Persons directly or indirectly employed in radio .....	250,000

Radio Figures Cont'd.

Newspapers publishing programs in U.S. ...	15,000
Radio Fan Magazines .....	20
Magazines publishing radio sections .....	40
Books published on radio .....	500
Persons employed on preparing and reading programs weekly .....	12,000

Sales of Sets and Parts  
(At Consumers' Prices)

Estimated number of radio manufacturers ..	2,000
Estimated number of radio dist. and jobbers ..	1,000
Estimated number of radio retail dealers ..	30,000
Sales of radio in 1920 .....	\$ 2,000,000
Sales of radio in 1921 .....	\$ 5,000,000
Sales of radio in 1922 .....	\$ 60,000,000
Sales of radio in 1923 .....	\$120,000,000
Sales of radio in 1924 .....	\$300,000,000
Sales of radio in 1925 .....	\$350,000,000

There are those, however, who question the foundation upon which the broadcasting industry is built. It lacks economic support, they argue, in the sense of direct returns. Nevertheless, broadcasting service, I believe, is now a prominent factor in the home. Various elements, industrial, social, religious and economic, have joined in the support of broadcasting in the United States. There are more applicants for broadcasting licenses than there are wave-bands to allot. Inadvertently or otherwise, broadcasting does give a return to those who undertake the service.

The facilities for a national service are being developed by demonstrations of super-power broadcasting. For while the local station is and must continue to be a most important factor in the broadcasting scheme, the fact remains that national features cannot be economically broadcast to limited audiences, and that there are many occasions in public life which demand national coverage. It is true that local stations may be and often are interconnected by wire, into a great communication link, but the preparations and costs are very formidable. Radio as a national system as well as international system of communications must be made responsive to every national emergency. It should not depend upon the wire plant of the country, which in emergency might itself be taxed to the utmost capacity. This is the significance of super-power development, which has come to be accepted much more sympathetically since I first urged this need at a conference in Washington two years ago.

And now having sketched as briefly as I might the progress which radio has made during the past few years, I would touch upon the delicate subject of patents. For after all, lasting structures are only built upon the solid foundation of property rights, and every valid patent represents the property right inherent in any investment of time, effort or money. The Radio Corporation of America alone has an investment thus far of over \$12,000,000 in radio patents, exclusive of the cost of continuous research and engineering which the development of the art has entailed. I merely call attention to the fact because it has a bearing upon the cooperation which industry, protected in its rights, can render to the Government. I have every sympathy with the thought that the Government in time of war cannot wait for the adjudication of patent rights. But in time of peace it would be a grave mistake to discourage the cooperation which industry can render to the Government by failure to appreciate the importance of patent recognition.

To complete the picture which commercial radio development presents today, I would review briefly the main lines of technical progress which the art is taking.

First, in the matter of telegraphy, duplex transmission appears to be the next step. We have demonstrated, experimentally at least, that two messages can be sent at the same time, on the same wave length, and with the same power. The technical elements that make duplexing possible also make secrecy possible.

Then there is high speed telegraphy, in connection with short wave transmission. In addition to observing the splendid work being done with short waves in our own country by the Army and Navy, one industrious amateurs and by commercial organizations, I also had opportunity to make a study of the subject in Europe last year. We have equipped every one of our high power stations with short wave transmitters, which are in use whenever short waves over long distances can be used. While long wave transmission still remains the only reliable method of trans-oceanic communication, nevertheless short wave transmission has at times given unusual results, getting through on occasion where long waves have failed, and this at reduced power and therefore at reduced cost of operation. But short waves are still in their experimental stage.

It is clear in this connection, as in other phases of radio transmission, that much as we may know of the construction of receiving apparatus and transmitting stations, we know very little of what happens in the space between. The mystery of the air still challenges scientific imagination.

In the matter of radio telephony, the next step, as is already amply indicated, will be international telephone connection across the oceans.

Great possibilities are held forth by the successful demonstrations of radio photography that have taken place during the past few years. Perhaps I can best illustrate some of the possibilities by an incident graven upon my memory, which occurred some years ago. Together with one of our technical experts, I was escorting Mr. Oswald Young, Chairman of our Board of Directors, through the RCA Radio Central on Long Island. We showed him the huge generators and transformers, the great steel towers, the high frequency alternators and explained the system in use. "Fine", he said "fine.. But how laborious and cumbersome are our present methods of communication, despite these great instrumentalities. What happens in telegraphic communication? First I transcribe my message on paper. Then you resolve the letters into dots and dashes. Again, at the receiving point the dots and dashes are formed into letters, the letters into words, the words into sentences, until the message is completed. What I would like to see is a system of transmission that could flash over to the other side a complete message or a whole newspaper page, if desired."

"It is splendid", remarked the technical expert, "to have an imagination utterly unrestrained by any limitations of technical knowledge."

Mr. Young's vision flew over a gap that took three years to bridge. Today we are preparing for the inauguration of a commercial service of radio photography across the Atlantic that will accomplish the results envisioned by him. Facsimile messages and photographs already have been exchanged by radio between New York, San Francisco and Hawaii.

Now that I have filled in as well as I might the more important details in the radio communications background, I feel somewhat in the unrestrained position of Mr. Young, except for his power of true vision. Possibly all that I can bring to the subject of radio in relation to national defense are further coals to Newcastle.

The fighting methods used by nations locked in the struggle of war have been radically changed only once during historic times. The general use of gunpowder did bring about a basic modification in military strategy and tactics. As long as man was restricted to the use of hand weapons, such as the sword, fighting methods were comparatively limited in their variety. After all, the soldiery at the Siege of Troy fought in no very different manner from the British archers at Agincourt.

Gunpowder made a big difference because it rendered the defensive armor of the middle ages obsolete and placed all men more nearly on a par as fighting units. This was perhaps the first striking illustration of the influence of science on warfare. It has, in fact, led to a very real change in military procedure, and has even brought about conditions practically amounting to a deadlock over extended areas and long periods of time when nearly equal forces of men were matched against each other. The opposing lines of men in the trenches during the Great War were immobilized because of the possibilities of the high power rifle and the machine gun, as well as artillery barrage. The development of this type of warfare is probably limited and we may now anticipate a real revolution in methods of fighting when all the agencies of science are concentrated on the development of destructive instrumentalities. Without, in the slightest, understanding the value of the physical agencies which proved effective in the last war, is it not reasonable to visualize the possibility that future great wars may well be fought and won on the basis of brains and scientific devices rather than numerical preponderance?

Startling, as this statement may seem, it is not inconceivable that a future great war may last five minutes rather than five years, and yet be infinitely more destructive and decisive than the last World War.

Consider, for example, a few of the possibilities which exist in offensive warfare along scientific lines. It is now conceivable that heavy charges of high explosives may be secreted under important governmental buildings, docks, factories, and other strategically important points, these charges being connected to radio receiving equipment capable of detonating the explosives when a certain secret code signal is sent on a particular wave length. If a potential enemy were to prepare in this way for anticipated hostilities, on the outbreak of war, he could readily send out the signal of destruction and to a considerable extent paralyze his opponent.

We know enough today about the radio control of remote mechanisms (the field of radioteledynamics) to expect, as development proceeds, unmanned airplanes, surface vessels, submarines, and land tanks carrying dangerously destructive explosives, poisonous gases, or disease-breeding bacilli could be aimed at the population centers of the enemy and sent to their destination in seconds.

The various forms of destructive radiation have not yet been worked out thoroughly, although we know that the X-rays and heat rays are extremely injurious in sufficient concentration. An investigation of these and perhaps as yet unknown rays, as well as other incendiary or disin-

grating agencies, may well lead to the development of extremely powerful methods of warfare.

The realms of destructive chemicals and of injurious bacilli have only begun to be developed and their potentialities may well be found to be very great.

In consideration of the possible development of the ultra-dangerous scientific methods of wholesale destruction, consideration of the appropriate counter measures should be taken by any prudent and patriotic people. If victory is to be largely influenced by scientific knowledge as well as military and industrial organization, it certainly follows that now is the time to study intensively scientific agencies of destruction, and perhaps even more vigorously the counter measures for combatting them on a wholesale defensive scale. This work cannot be completely developed by civilian industrial companies. In the first place, it is a highly specialized field and requires a detailed and confidential knowledge of military problems and methods. In the second place, it is considerably removed in its early stages from any commercial application, and the considerable expenditures of time, energy and money which are involved in such work would not be normally undertaken by industrial concerns, without some direction by Government agencies.

On the other hand, the personnel necessary to carry forward scientific military research must be drawn from the universities and the great industrial concerns of the United States. It may well be that the scientists and engineers should be borrowed by the Military Department from time to time. Also it is not unlikely that their military research would have some by-product results capable of commercial application, and the reverse may also be desirable, that is, military experts might well be assigned at regular periods, for some training and experience at commercial laboratories and plants.

Some of the fields of research which require attention by such a military scientific group are the remote control of mechanisms, the production and rapid transmission by wire, radio or otherwise of photographs, radio direction finding on all wave lengths, the further development of secret methods of communication, the study of all forms of offensive radiation, chemicals, and other substances, and the development of protective measures against each of these offensive devices. To carry forward such work would require the coordination of existing or the establishment of new optical, electrical, chemical and biological research laboratories, and the placement of recognized experts in their respective fields on the staff of such laboratories.

A special offshoot of the main problem of scientific preparedness is the question of the effective utilization of our existing radio resources during a war. The status of broadcasting, in particular, is peculiar. Millions of receiving sets have been placed in American homes and they are not licensed by the Government. Their nature and location is therefore practically unknown and they are, in fact, very readily concealed. They have become as much a part of the life of the community as the newspaper or other agencies of instruction and entertainment.

During the Great War, radio reception by the public was prohibited. This would be a mistake under the conditions which may obtain during any future hostilities. It is far better to utilize the capabilities of radio broadcasting than to discard them. Of course, radio broadcast transmission would have to be strictly controlled by the government under war-time conditions, but reception should be permitted. It would be possible for the government to issue expeditiously and simultaneously, reports and stimulating announcements to many millions of listeners and possibly the entire nation. In cases of airplane raids or other impending attacks, instantaneous warnings could be issued which would reach the entire population practically instantly. Announcements dealing with mobilization and other military matters could be broadcast and, by the appointment of a definite hour at which such announcements would be broadcast, there could be in effect a daily military bulletin service of high efficiency and universal scope.

On the other hand, it is reasonable to assume, that with the advent of International Broadcasting and the further development in this field, which is sure to follow, the enemy may, in time of war, be able to have direct access to the homes of citizens and other residents in the country, with consequent possible dangers which should be carefully considered. Means can, no doubt, be developed and provided for dealing with radiations from enemy countries but this will follow only after a clear recognition of the existence of this problem.

It is certain that the existence of millions of receiving sets in the homes of the citizens of this country, together with the availability of great interconnected networks of broadcasting stations, will place at the disposal of the government during any possible later war a most powerful weapon for organization and the maintenance of national morale. And this very fact, also, makes it necessary to perfect plans whereby the enemy's waves of sinister propaganda may be under control.

Briefly, then, the United States needs manpower and it needs industrial organization but, to my mind, as important as these and possibly even more so, it also needs scientific research and preparedness to meet the military problems of the future which are sure to be infinitely more complex and destructive than those of the past.