# Developments in High-Power Radio

## And Its Practical Application in the Services of the United States Navy

By COMMANDER STANFORD C. HOOPER, U. S. N.
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APPROXIMATELY twenty-five years ago, or to be exact, in February of the year 1896, a young scientist of Italian and Irish parentage journeyed from Italy to England in the hope of interesting the British Government in an invention by the use of which the claim was made that communications could be exchanged between distant points without utilizing the ordinary connecting wires or other visible connecting medium.

Doubtless he experienced some difficulty in getting in touch with the government officials in London, and, presumably, when he did, his claims were listened to with a degree of skepticism comparable to that which would probably now confront a man who suddenly claimed to have exchanged communications with inhabitants on the Moon. It would be only natural that such an attitude would prevail because the only method then known for exchanging rapid communications between points separated by distances considerably beyond the range of visibility was to utilize the land line wire telegraph, telephone, or ocean cable systems, and it was generally believed to be impossible to exchange rapid communications over great distances without utilizing connecting wires.

However, the expression "wireless telegraphy" or communications without wires, naturally envisaged communications with ships at sea and between ships separated by great distances at sea, and doubtless the authorities of the leading maritime power of the world would not let pass any proposition, however fantastic, that might possibly bring this about.

Needless to say, the young inventor to whom reference has been made was Marconi.

We learn that six months after Marconi arrived in England he conducted a series of trials before the British Post Office officials and navy and military officers on Salisbury Plain, and succeeded in establishing communication over a distance of one and three quarter miles. About one year later Marconi increased this distance to four miles, and a few months later he increased the distance to eight miles.

Thereupon news of the performances of the young inventor began traversing the ocean cable systems of the world radiating from London (the cable systems themselves having been in successful operation only about twenty-five years) and a skeptical world was apprised of the remarkable new invention of "wireless telegraphy."

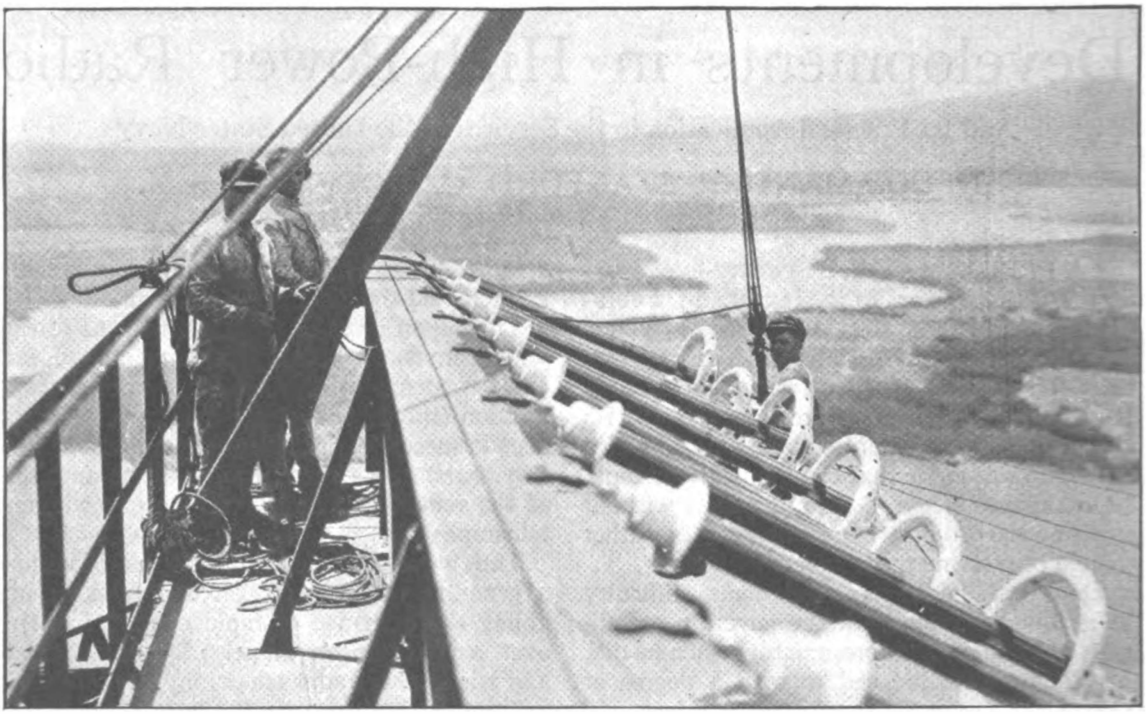
Thus we see introduced into the world within a generation two remarkable inventions enabling the exchange of rapid communications over long distances, namely, the ocean cable and wireless, or radio telegraphy.

Now, after these systems have been developed and largely perfected, we find ourselves on the threshold of another remarkable development in connection with the exchange of rapid communications over long distances, namely, wireless telephony or the radiophone, about the future possibilities of which it is difficult to hazard even a conservative prediction.

Obviously the world is advancing rapidly and with great strides in the development and inauguration of new means for exchanging rapid communications over long distances, thereby linking the remote regions of the world together with the less remote regions, bringing the more backward peoples into close contact with the less backward; in fact, gradually consolidating all the peoples of the world into one great human family by providing channels for readily exchanging rapid communications.

As a matter of fact, the shortening, in effect, of the vast intervening distances separating the different principal parts of the world, and the opening up of regions hitherto regarded as more or less inaccessible, as a result of the inauguration of the new methods of exchanging rapid communications, has already come to be regarded as so commonplace as not to excite unusual interest or comment.

During the interval of time from the year 1897 to 1912, developments took place in wireless or radio telegraphy so rapidly that the



Riggers replacing a defective insulator in the Navy's Pearl Harbor high power radio station antenna

range of communication increased from eight miles to as much as three thousand miles under the most favorable conditions, and the application of this method of communication to practical uses, particularly in connection with sea-going ships, especially as regards the preservation of life at sea had been amply demonstrated by the rescue of the passengers and crew of the ill-fated American passenger steamship *Republic* on January 23, 1909, before that vessel went down, assistance having been summoned by the stricken vessel by wireless.

About three years later, or on April 15, 1912, the lamentable *Titanic* disaster occurred. It will be recalled that the one radio operator carried by the steamship *Carpathia*, while he was preparing to retire for the night, but while still wearing his radio headphones, almost accidently overheard the radio distress calls, or S. O. S. signals, of the *Titanic*, and as a result, the *Carpathia*, after steaming at full speed throughout the night, arrived in the early morning hours at the position previously given by the *Titanic* and rescued the occupants of the *Titanic's* boats after the great vessel had gone down in mid-Atlantic carrying with her a large number of her passengers and crew. The *Titanic* disaster convinced the world of the inestimable value of radio as an agency to safeguard life and property at sea, and it resulted in much beneficial legislation being enacted by the various governments of the world, especially as regards the equipping of sea-going passenger-carrying vessels with reliable radio outfits and also the carrying of more than one radio operator. The very great value of radio in naval and military tactics and as an agency to influence world trade was also coming to be generally recognized, and plans began to be formulated by the various leading powers of the world, notably by Great Britain, Germany, and the United States, with a view to establishing chains of high-power radio stations on shore to meet the national and trade requirements.

Germany undertook the establishment of a high-power station in the United States to work with a similar station near Berlin. Great Britain contemplated an "Imperial Wireless Chain" designed to connect all of her outlying possessions with England by radio.

The United States Navy established its first high-power station at Arlington just outside of Washington as the terminus of a projected trans-Continental trans-Pacific High Power Circuit to connect the Navy Department by radio with our Atlantic, Pacific, and Asiatic Fleets and to afford our government a means of communicating with our outlying possessions in the West Indies, the Panama Canal Zone, Alaska, the Hawaiian Islands, Samoa, Guam, and the Philippines, either directly or through intermediate radio relay stations, and entirely independent of cable facilities.

The Navy's main high-power circuit was to comprise, in addition to the Arlington station, primary high-power stations at points on the California coast, in the Hawaiian Islands, and in the Philippines. It was hoped that reliable trans-Continental service could be maintained between the Arlington station and a primary station on the California coast, thence with Hawaii and thence with the Philippines.

Secondary high-power stations in the primary chain were planned, one for the Canal Zone, one for the West Indies, one for Alaska, one for Samoa, and one for Guam, to work with Arlington direct or through one or more of the primary stations. Other stations of medium power were planned, but these nine stations were to be the principal reliances or key stations for exchanging communication with our three Fleets and with our outlying possessions.

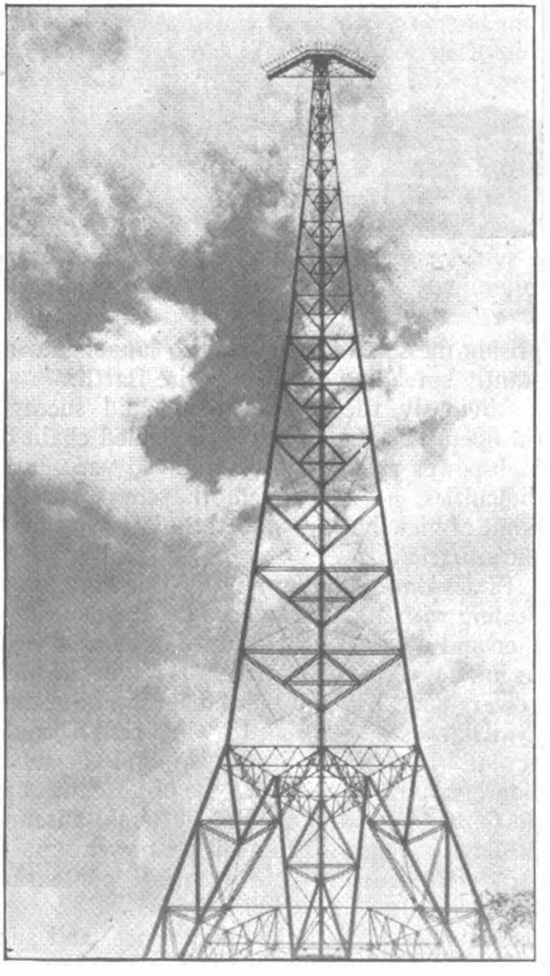
Work was gotten under way without delay, and within five years all of the eight remaining stations were completed and placed in operation as were also several less important stations.

These nine key stations are located at Arlington in Virginia, Darien in the Panama Canal Zone, El Cayey in Porto Rico, San Diego in California, Pearl Harbor in the Hawaiian Islands, Cordova in Alaska, Tutuila in American Samoa, Guam in the Mariana Islands, and Cavite in the Philippine Islands.

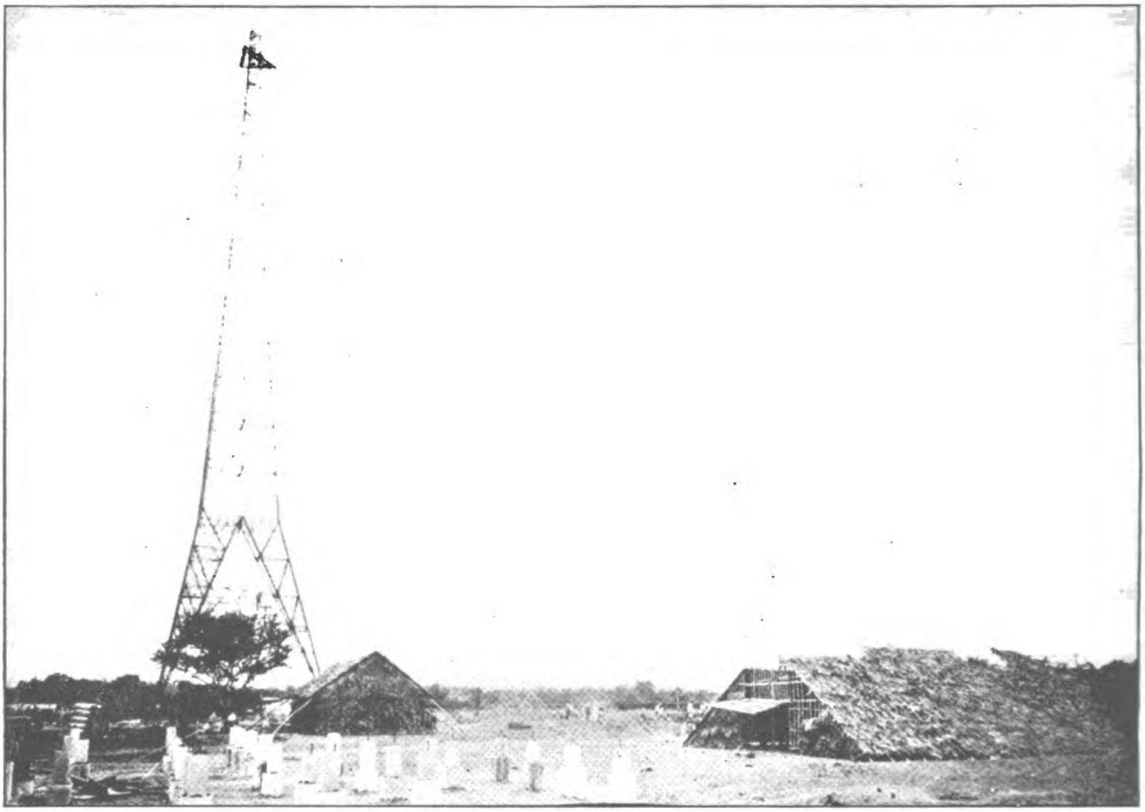
These stations, extending nearly halfway around the world, have been maintained in daily operation since their establishment and they have rendered the service originally expected and required of them, with the exception of the Arlington station, this station having been supplanted as the terminus of the high-power circuit by the more powerful station subsequently established at Annapolis, Maryland.

Thus it will be seen that within an interval of about twenty-five years after Marconi's epoch-making demonstrations when he signalled, without utilizing connecting wires, over distances of from one to eight miles, the United States Navy had in daily operation in the services of its Fleets and the Government in general, a chain of radio stations whose signals constantly were encompassing the globe, this chain of stations being the most widely extended, most effective and reliable, and comprising the greatest number of high-power radio stations of any country in the world.

The effective working ranges of these stations throughout all periods of the day and night and all seasons of the year is from 2,000 miles for the less powerful stations to 6,000 miles for the most powerful stations, such as the Cavite station in the Philippines; and these effective ranges, together with the widely separated locations of the stations and the fact that they are operated practically continuously, results in electrical impulses corresponding to the "dots" and "dashes" of the radio code com-



Upper section of one of the Navy's standard 600-foot self-supporting towers extending high up into the clouds. Note that the large antenna insulators are barely visible



The application of science in the forward march of civilization. View of 600-foot self-supporting steel tower being erected among the native huts at Cavite, Philippine Islands

prising messages in the English language constantly spreading over the entire Earth.

Obviously the establishment and successful operation of this widely extended chain of high-power radio stations involved very great difficulties, not only from the constructional point of view but also the technical aspects of the situation.

In a pioneer undertaking of this kind when dealing with a new art whose development was then and is now rightly regarded as being only in its infancy, especially as regards the use of high power, very little authentic information was available as a guide as to what results could actually be expected in service, and the question of the most suitable type of antenna supports, antenna and ground systems, antenna insulators, types of transmitter, power supply, etc., were matters of theoretical contention based largely on personal opinions.

Time has proven that experience, and successful experience alone, is the only true guide in designing a radio system. This experience was not then available to the Navy. Nothing is easier than to take a map, mark out radio station sites, connect them by straight lines and call the arrangement a radio system; but nothing is more fallacious in radio. The type of transmitter to be adopted was, of course, of very great importance, as was also the type, height, and location of antenna supports. Other important features could be modified, if required, after the stations were placed in service without involving excessive interruption to service; but it would be an extremely difficult and costly matter to replace transmitters or to rearrange the antenna supports.

One of the fundamentals in radio technique is that the strength of signals at a distant receiving station is dependent upon the effective height at which the overhead wires of the antenna system are suspended above the earth, and the value of the current delivered to the antenna without causing brushing or corona formation at the transmitting station.

Obviously, therefore, regardless of all other considerations, it is always desirable to suspend the transmitting antenna the greatest distance that is possible above the earth, to insulate effectively the antenna from its supports, and to deliver the greatest possible current value from the transmitter into the antenna for communicating over long distances such as distances of 2,000 to 6,000 miles.

Three types of antenna supports were available from which a selection could be made, namely guyed wooden lattice masts, guyed steel pipe or steel lattice masts, and self-supporting steel towers.

A variety of factors must be considered in the selection of the type of antenna supports to be used, particularly at high-power stations, where the initial cost and subsequent upkeep must be given careful consideration, such as the area of the ground available for the station site and the cost required to purchase, if not already available, the availability, locally or otherwise, of suitable timber, in the case of wood masts, transportation facilities and labor costs, intensity of prevailing winds, nature of soil in connection with foundations, etc.

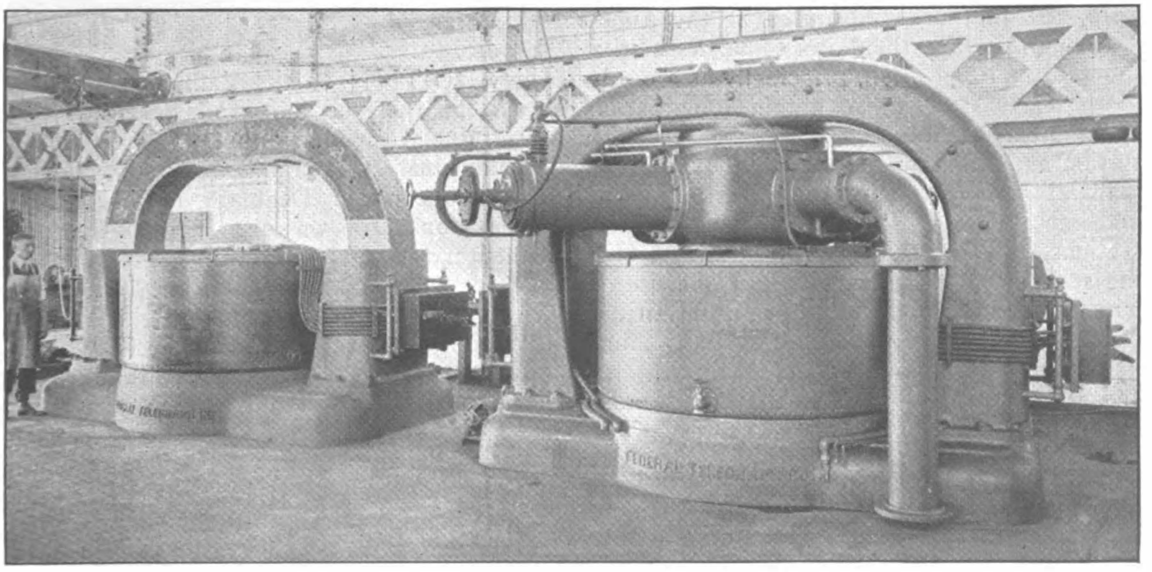
The Navy decided on self-supporting steel towers as antenna supports in preference to steel or guyed wood lattice masts in the interests of permanency, dependability, and comparative low cost of upkeep, notwithstanding the fact that the effective antenna height would be reduced thereby in the order of 15 per cent. as compared with guyed wood masts.

The tower height was fixed at 600 feet and to be of sufficient strength to withstand a horizontal antenna pull at the top of 20,000 pounds. Three towers were decided upon for each station, the towers to be erected at the apices of a triangle 1,000 feet on a side.

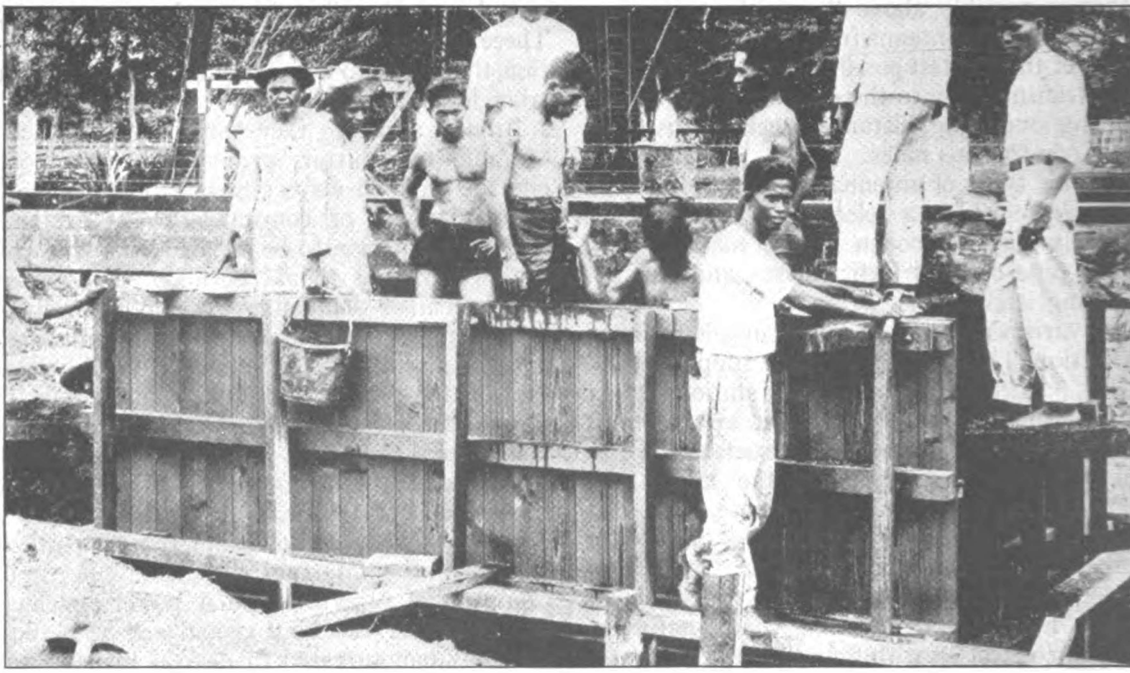
Broadly speaking, there were only two classes of radio transmitters available for selection, one the damped wave system, and the other, the undamped or continuous wave system. The first question to be decided was which of the two systems should be adopted, whether the system of damped waves, or the system of undamped or continuous wave transmission, and the second queston was the selection of a type of transmitter of the system decided upon.

The damped wave system as originally used by Marconi, based on the earlier experiments of Hertz, had been in general use in the radio services of Great Britain, the British Marconi Company and its various affiliated companies, including the Marconi Wireless Telegraph Company of America, for low power and medium power stations but it had not been successfully demonstrated for use in high power stations to work reliably over long distances.

In the damped or spark system of radio telegraphy the antenna is given a series of electrical impulses of considerable intensity but of very short duration at comparatively infrequent intervals, and the average power is thus a very small fraction of the maximum. If communications are to be exchanged over extremely long distances, the energy to be handled during one of these impulses becomes



View of the Cavite and Pearl Harbor arc converters under manufacture and assembly at the Federal Telegraph Company's factory at Palo Alto, California



Native Filipinos working on the construction of the Navy's high power radio station at Cavite, Philippine Islands

so large as to be impracticable. Moreover, as a result of the increment and decrement of the oscillations, the effect of the method is to produce the simultaneous radiation of a wide range of wavelengths, or very "broad" waves, which seriously interefere with receiving stations which may be attempting to copy the signals of other stations. These facts were not generally recognized as early as the year 1912, but they are undisputed at this time.

About this time the Navy found itself in a most fortunate position, principally as a result of the early start it had obtained in the establishment of the high-power 100-kilowatt station at Arlington, and also two medium 25-kilowatt stations, one at Key West, Florida. and one at Colon in the Canal Zone. These stations, together with various other receiving stations, provided facilities by the use of which the relative efficiencies of transmitters of the damped and undamped systems could be tested under actual service conditions, and the results of these tests, when undertaken, proved conclusively that the undamped wave system was far superior for long-distance work.

Spark or damped wave transmitters had been installed in the Arlington, Key West, and Colon stations, a Fessenden synchronous spark set at Arlington, and similar, but smaller sets, at Key West and Colon. The various stations were operated daily in service and the reliability and quality of the service under regular operating conditions and varying atmospheric and seasonal conditions had been determined.

Spark sets of from one half to five kilowatts power had also been installed in many other stations ashore and on shipboard, but these three stations represented what were then considered to be high-power stations.

### THE ARC SYSTEM

IN ADDITION to the damped, or spark system, there became available, about this time, the undamped arc system as invented by Dr. Valdemar Poulsen and Prof. P. O. Pedersen of Copenhagen, Denmark, in 1902. This type of transmitter was just emerging from the elementary stages, and had not yet been developed for powers greater than thirty kilowatts.

An American radio company, the Federal Telegraph Company which had recently been formed, had purchased the exclusive rights in the Poulsen arc system for the United States and had also purchased two arc sets from the Danish Company, one set rated at five kilowatts and one at twelve kilowatts. The Federal Telegraph Company established a laboratory and factory at Palo Alto, California, for the purpose of developing and manufacturing arc radio transmitters, and undertook the establishment of a few low-power stations along the Pacific Coast of the United States.

The Federal Company also established a 30-kilowatt station at San Francisco and a similar station at Helia in the Hawaiian Islands, for trans-Pacific service. Fairly reliable service was established between the United States and Hawaii through these stations, the distance being approximately 2,500 miles.

The Navy's station at Arlington constituted at this time the most pretentious high-power radio station in the world, and while its signals could be heard over distances of 5,000 miles under the most favorable conditions, that is, at night during the winter months, the service was far from satisfactory during all periods of the day and night, and during all seasons of the year for distances of 2,000 miles.

The Arlington station, in which a 100-kilowatt damped wave set was in operation, and whose antenna was supported by one 600-foot and two 450-foot towers, made available most excellent facilities for a test of the spark or damped wave system of radio telegraphy as compared to the arc or undamped wave system.

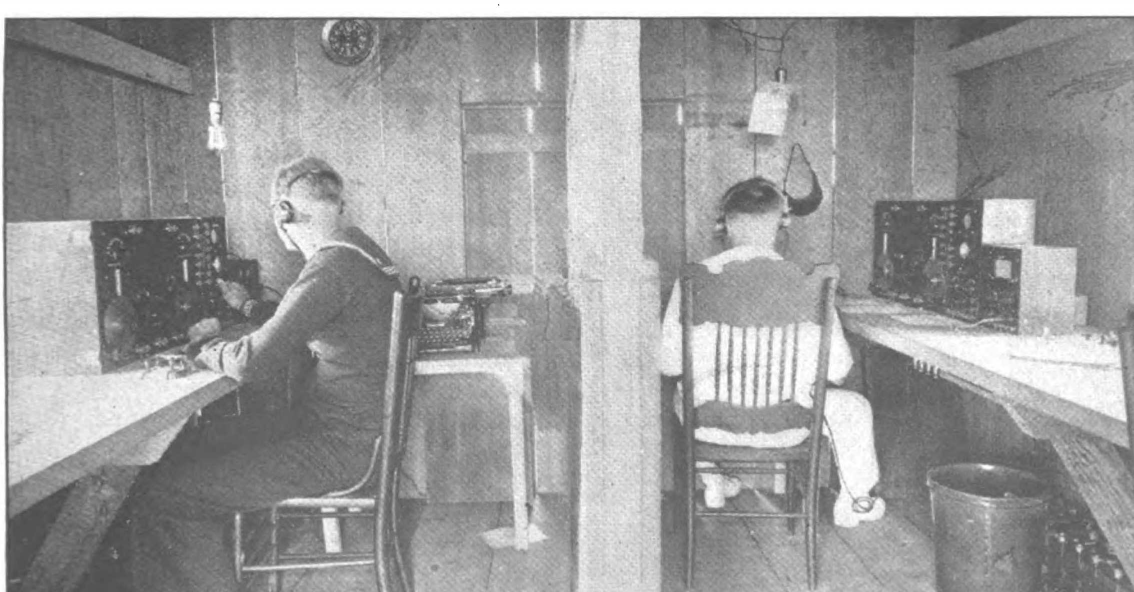
### COMPARISON OF SPARK AND C. W. TELEGRAPHY

ARRANGEMENTS were therefore made with the Federal Telegraph Company for the installation of one of their most powerful transmitters, a 30-kilowatt set, in the Arlington station for comparative tests. In addition to the comparative audibility of the signals from the 100-kilowatt spark and 30-kilowatt arc Arlington installations at Key West and Colon and various other distant receiving stations, comparisons could also be had of the 25-kilowatt spark signals from Key West and Colon at the Arlington station.

Upon completion of the arc installation at Arlington, an antenna current of slightly more than 50 amperes was obtained, as compared to slightly more than 100 amperes obtained with the spark set. Notwithstanding this difference in antenna current in favor of the spark set, the average received signal strength of the arc set at Key West, Colon, and other distant stations exceeded that of the 100-kilowatt spark set under the varying conditions imposed during the observations.

The signals of the arc were audible at San Francisco and even at Pearl Harbor under most favorable conditions, the distance between Arlington and Pearl Harbor being approximately 5,000 miles. This demonstration clearly indicated the superiority of the undamped wave system of radio telegraphy over the damped wave system, particularly for use over long distances, and it proved to be the determining factor which influenced the Navy

Naval radio operators on duty in the receiving "hut" of the Navy's trans-Pacific high power station at Cavite, Philippine Islands

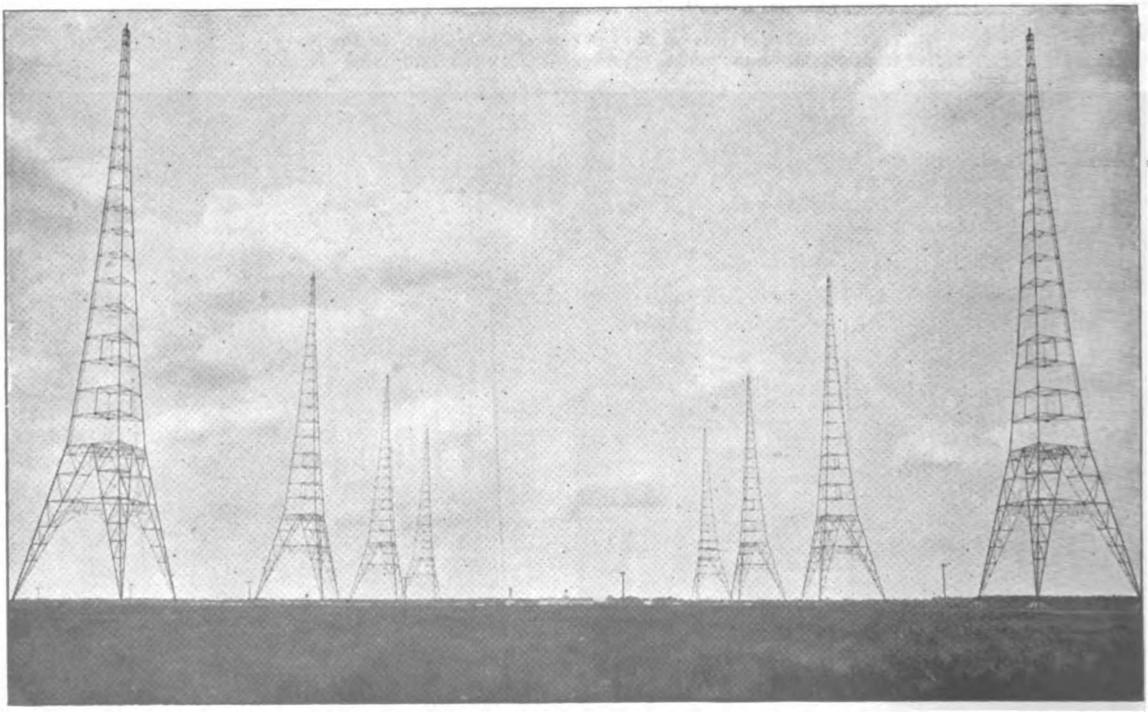


in the selection of the type of equipment to be employed in its high-power stations. As a further check and assurance as to the superiority of the arc, the cruiser *Salem* was dispatched on duty in the Atlantic Ocean, and exhaustive receiving tests were made on this vessel comparing the signal strength and quality of the Arlington spark and arc installations. The results of these receiving tests at sea confirmed, without the shadow of a doubt, the results of the previous tests made by distant stations on land. During the cruise of the *Salem*, the signals from the Arlington arc set were of readable audibility all the way to Gibraltar, whereas the signals emitted by the spark set were not at all times readable and at times were so extremely weak as to be scarcely audible, although the spark set employed more than three times the energy of the arc set.

The arc set was purchased from the Federal Telegraph Company and allowed to remain in the Arlington station. Shortly afterward a contract was awarded to that company for a 100-kilowatt arc transmitter, for installation in the projected high-power station for the Canal Zone to be established at Darien midway between Colon and Panama City, this action being taken in spite of powerful opposition by commercial radio interests which were interested in the manufacture of the damped wave or spark transmitting equipment. The Darien set was the result of developments carried on in the United States in connection with the production of arc radio transmitters for high power, and further developments were undertaken resulting in the gradual production of 200 kilowatt sets for the San Diego station, 350 kilowatts for the Pearl Harbor station, 500 kilowatts for the Cavite station and the Annapolis station, and finally 1,000 kilowatt sets for the Lafayette station, the establishment of which the Navy undertook at Croix d' Hens near Bordeaux, France, during the war, as a precaution to insure the maintenance of uninterrupted communications with our Expeditionary Forces in the event of the cutting of the transatlantic cables by submarines.

(*To be Continued*)

1000-Kilowatt super high-power radio transmitting station erected by the U. S. Navy at Croix d'Hens, near Bordeaux, France, during the war to insure facilities for rapid communication between the U. S. Government and our Expeditionary Forces in France in the event of the expected cutting of the transatlantic cables by submarines. Eight 820-foot self-supporting steel towers as radio antenna supports, each tower weighing 550 tons or a total of 4,400 tons of fabricator steel support aloft an antenna weighing 3½ tons. Will this station eventually be developed into a world wide radio telephone station?



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## PART II

THE passage by Congress of the Naval Appropriation Act of August 22, 1912, contributed greatly to the advancement of the radio art as regards the development of high-power radio, not only in the United States but throughout the world. It gave to the Naval radio service a great opportunity, but it also placed a heavy responsibility on those entrusted with the direction and administration of the service.

This Act appropriated $1,500,000 for the establishment of six of the Navy's projected high-power stations, those to be located in the Isthmian Canal Zone, on the California Coast, in the Hawiian Islands, in American Samoa, at Guam and in the Philippines. This constituted a programme of great magnitude in high-power radio construction and one which obviously was difficult of accomplishment at that period. The trail had not yet been blazed in this direction and little information of a practical nature was available. The Arlington station was under construction but had not yet been finished; so that definite information was not available as to what could be expected from a station of this type.

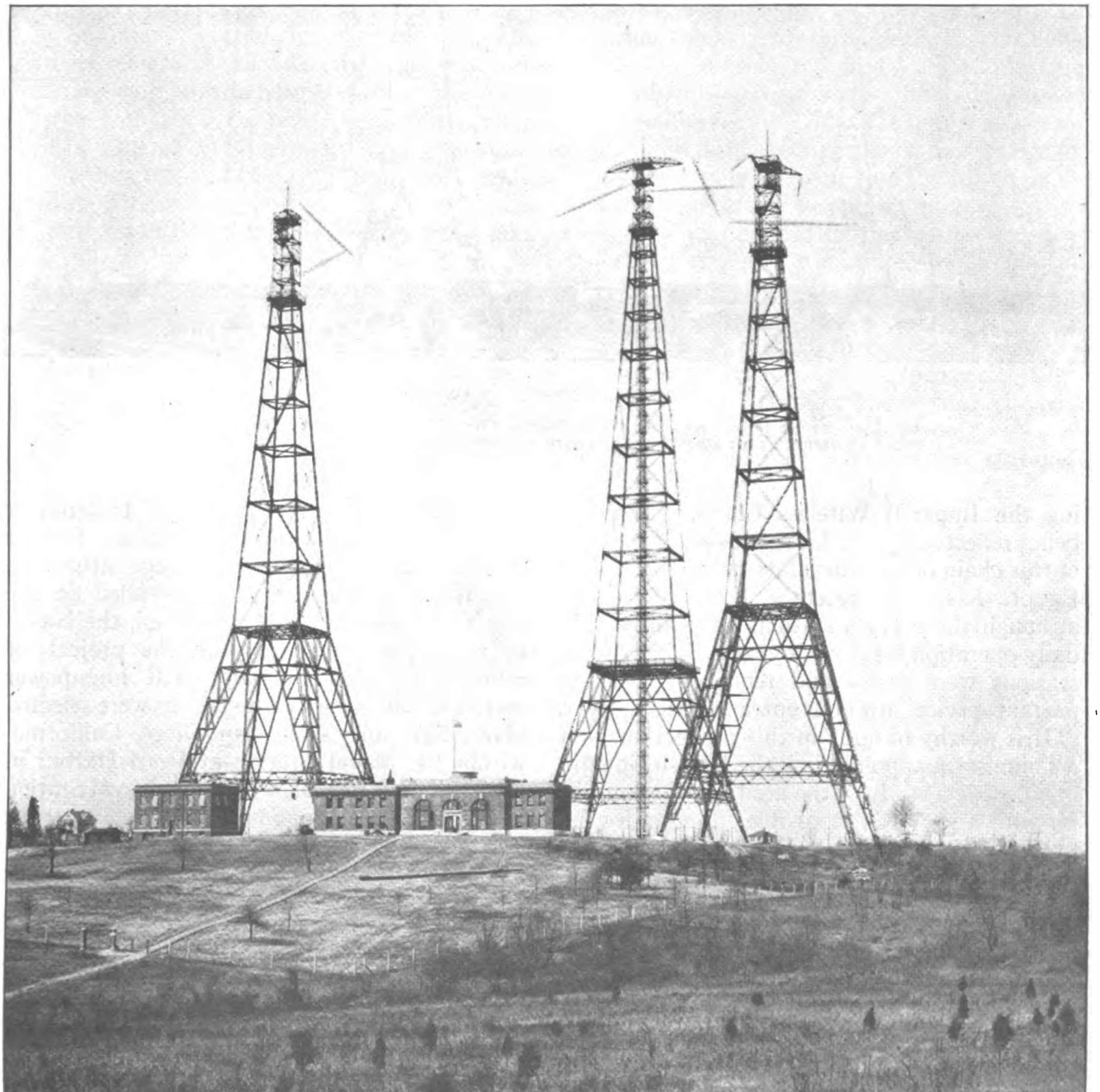
The plans for the six new stations therefore must necessarily be held in abeyance pending the completion and testing of the pioneer high-power Arlington station. Being a pioneer in substantial high-power radio construction, this station must be regarded in the light of an experiment. Because of insufficient scientific knowledge at that time, mistakes were made in the establishment of the Arlington station, principal among which were locating the station on high ground and placing the steel towers too close together, but nevertheless this station has rendered most valuable service to the Government ever since it was placed in commission, and moreover it served as a guide by which similar mistakes on a larger scale were avoided. It also made available a high-power station for testing different types and makes of apparatus in actual service, thereby enabling the selection of the most efficient type of equipment available for service at that time. It was, in short, the agency by which delay was avoided in establishing the extensive radio system required to meet the needs of our Atlantic, Pacific, and Asiatic Fleets and other government agencies.

The Arlington station may justly be regarded as the pioneer development in high-power radio in the world, as well as the fountain head of the Navy's existing radio service, a service of which the stations on shore extend more than one quarter the distance around the world and whose signals are constantly encompassing the globe. The true significance of the Arlington station will not be fully appreciated until the history of radio is finally written.

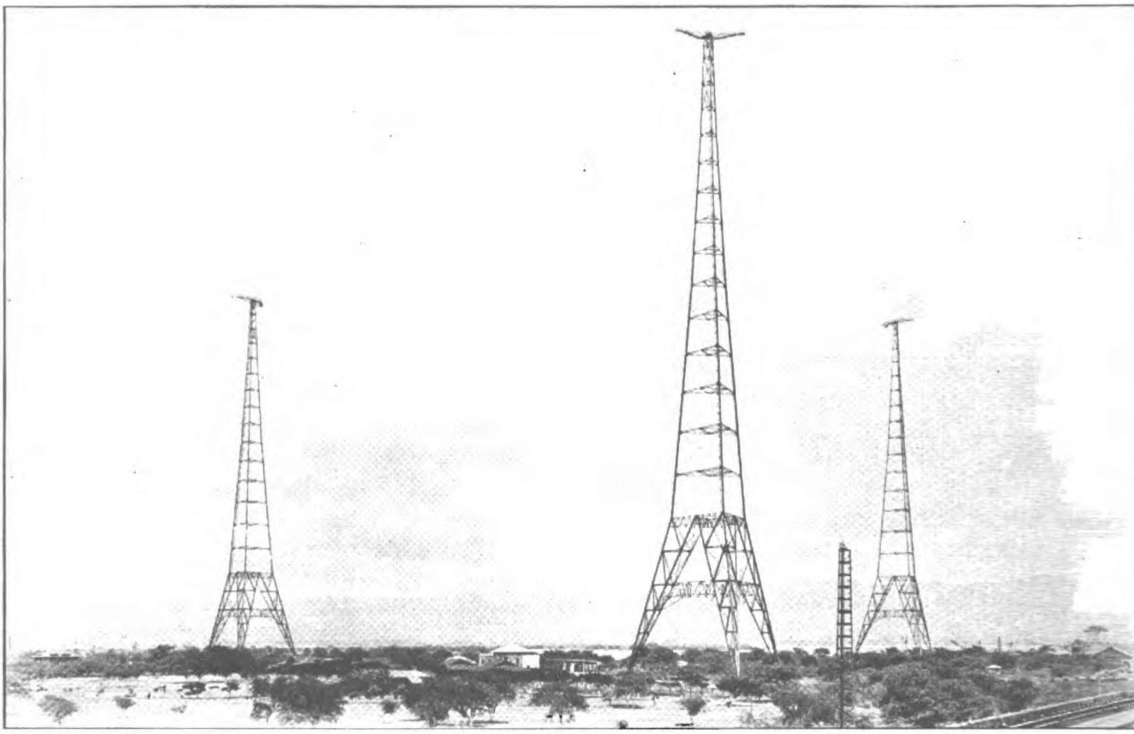
### THE POULSEN ARC TRANSMITTER

UNDOUBTEDLY the second feature of importance in connection with the development of radio in the United States, especially as regards high power, is the Poulsen-Federal arc converter. This type of transmitter, successfully developed by the ingenuity of American radio engineers from powers of 30 KW to 1,000 KW within a brief interval of ten years, and manufactured in the United States, is the outstanding unit of apparatus in the Naval radio service. Arc transmitters have given satisfaction in the services where they have been employed for powers from 2 KW to 1,000 KW. The Navy has used this type of apparatus in its high-power stations continuously since the first 30-KW arc transmitter was tested out in the Arlington station ten years ago. Arc transmitters produce harmonics as do other types of transmitters. They also produce a form of interference called "mush," the cause of which is not yet thoroughly understood. Two waves were also radiated, instead of one, in the system of signaling originally employed. All three undesirable features are gradually being eliminated, however, and it is expected that the arc will then radiate as pure a wave as any of the other existing transmitters.

By originally adopting the arc transmitter for its high-power stations, the Navy has obtained satisfactory service from the beginning and it has not yet become necessary to replace the original installation in order to keep abreast of the progress in radio. It thereby avoided the expense which the Marconi Wireless Telegraph Company of America (now the Radio Corporation of America) found it necessary to assume when that company was obliged to scrap practically new spark transmitters and install alternators in all its high-power stations in order to carry on transoceanic traffic satisfactorily. It also avoided long delay in establishing its transcontinental, transpacific chain of high-power stations such as has been experienced by the British in establish-



ARLINGTON
Probably the best known radio station in the world. All manner of new developments are tried out by the Navy at this station. Mariners listen for its time signals and weather reports the world over



PEARL HARBOR, HAWAII
The U. S. Navy high-power station in mid-Pacific. It is not uncommon for experienced amateurs as far away as our eastern seaboard to copy messages from this giant

ing the Imperial Wireless Chain, this delay being reflected by the fact that one of the first of this chain of outlying stations, that at Cairo, Egypt, has only recently been completed, although the Navy's stations have all been in daily operation for several years. The Navy's stations were ready and rendered most important services after our entrance into the war.

It is worthy of note, in this connection, that a commission appointed by the British Government made a study of the arc type of transmitter with a view to its possible adoption for use in the stations of the Imperial Wireless Chain, about the same time the Navy was investigating it for use in its high-power stations. The British Commission's report, which was promulgated after the Navy had definitely decided to adopt the arc, was to the effect that this type of apparatus was unsatisfactory for the purpose intended and it was therefore not recommended for use. Notwithstanding this fact, the arc transmitter is now being installed in stations in the Imperial Wireless Chain.

Vested with the authority granted by Congress in 1912 and being satisfied with the performance of the arc type of transmitter as a result of the Arlington tests and further extensive tests carried on subsequently with the 100-KW arc converter installed in the new Canal Zone station at Darien, the Navy, in 1914-15 went ahead with the project of establishing the five additional high-power stations. Sites for these stations were selected about five miles from San Diego, California, within the Naval Station at Pearl Harbor in the Hawaiian Islands, within the Naval Station at Tutuila, American Samoa, at a point about five miles from Agana on the Island of Guam, and within the Naval station at Cavite about twelve miles from Manila.

Three-legged, self-supporting steel towers, similar to those designed for the Arlington station, were erected at all of the stations with the exception of Tutuila where 300-foot wood, guyed, lattice masts were used, owing to insufficient funds for steel ones. Three 600-foot towers were erected at the San Diego, Pearl Harbor, and Cavite stations. Two 450-foot towers were erected at Guam. Two 300-foot wood masts were erected at Tutuila.

A 200-KW arc converter was installed at Challas Heights, 350-KW at Pearl Harbor, 500-KW at Cavite and 30-KW at Tutuila and Guam.

All five stations were completed and in commission within two years thereby linking our most distant possessions, the Philippines and other islands in the Pacific with Washington by radio. As a result of the establishment of this chain of high-power stations and with the stations at Cordova, Alaska and Cayey, Porto Rico, subsquently established, and the replacement of the Arlington station by the more powerful Annapolis plant, the Navy Department is enabled to keep in constant touch with our three fleets, with their auxiliaries and with their bases. The Government now has a system of communication radiating from Washington and covering our entire coasts and our outlying possessions, a system entirely independent of the land lines and the meagre cable facilities in the Pacific.

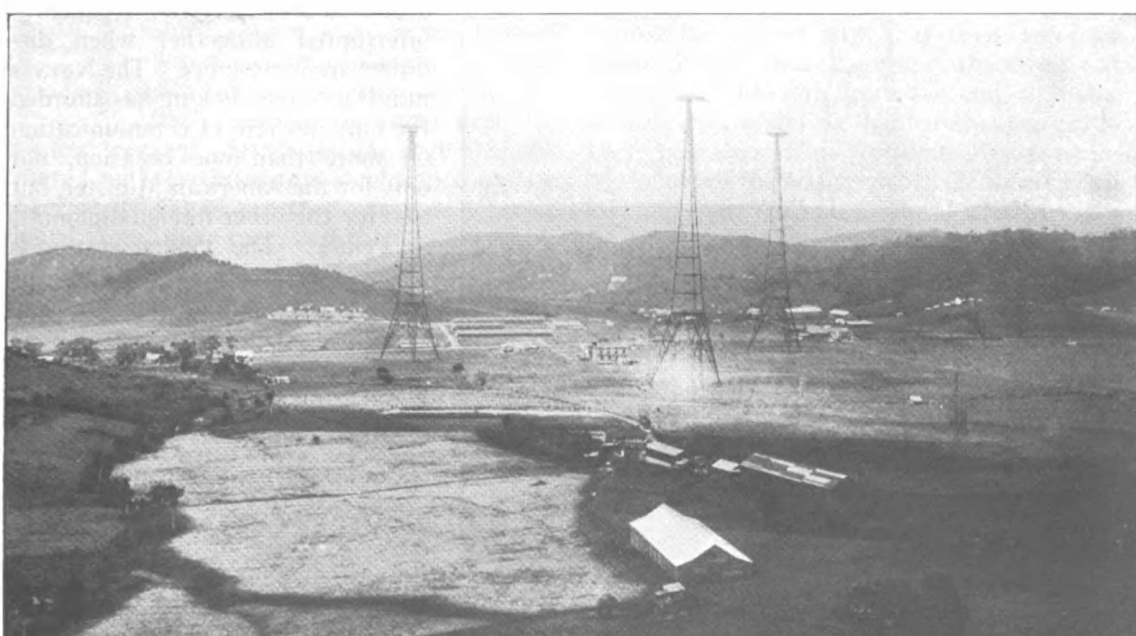
The Naval radio service is used by all the government departments and agencies. It serves the Army for communicating with its forces in the Philippines and our other possessions in the Pacific, with the Canal Zone and the West Indies. It serves the Weather Bureau, the Bureau of Lighthouses, the Bureau of Fisheries, the Coast Guard and similar government agencies. It provides channels of communication with our outlying possessions which make them entirely free of foreign-owned or controlled cables and therefore it is a potential asset for the development and fostering of our trade.

The Naval radio service normally handles approximately 20,000 words per day across the Pacific, this volume of traffic being greatly increased during cable breaks. About 5,000 words are normally handled between Puget Sound, Washington, and Cordova, Alaska, and when breaks occur in the Army's cable between Seattle, Washington, and Valdez, Alaska, the number of words averages between 30,000 and 35,000 per day. About 8,000 words are exchanged daily through the Darien station in the Canal Zone and about 5,000 words through the Cayey station in the West Indies.

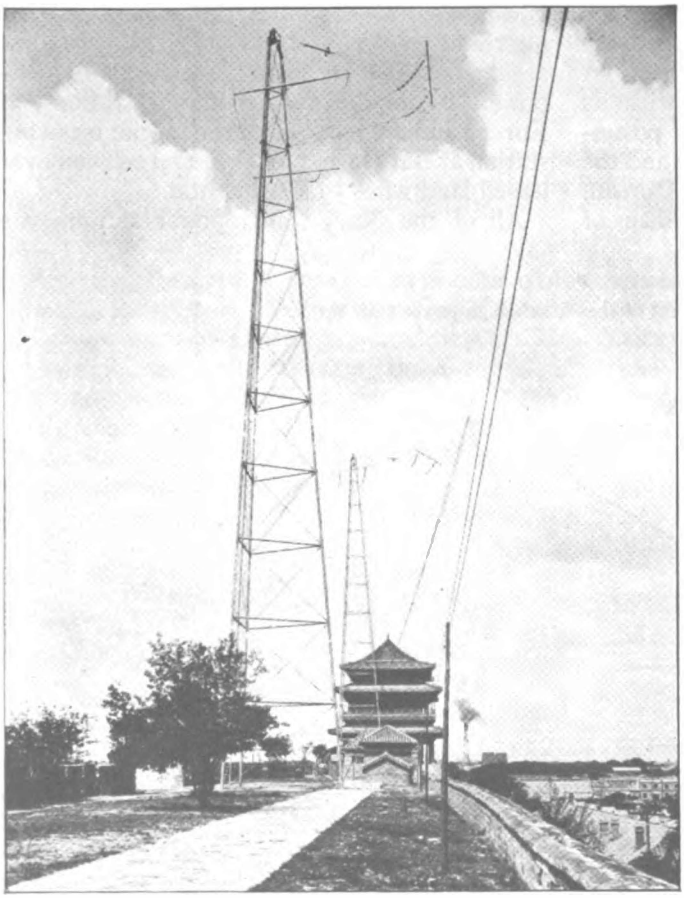
Messages are constantly passing between the various coastal stations on shore and naval and merchant vessels at sea. Government messages are sent daily from the Annapolis high-power station to corresponding stations in Europe and are received at the special receiving station at Bar Harbor, Maine, and relayed over leased land wires to Washington.

All of the Navy's high-power stations are

CAYEY, PORTO RICO
The Insular outpost of the Navy's high-power system



operated duplex to enable messages to be received at the same time other messages are being sent from the same station or unit. This is accomplished by establishing a control and receiving station at a distance of about ten or twelve miles from the transmitting stations and connecting the two stations by land wire telegraph. Radio men are posted at the transmitting stations to start and stop the machinery and to regulate the apparatus, the functioning of which for transmitting messages, however, is controlled by the operator at the central and receiving station. In practically all the Navy's high-power stations there are installed a medium-power and a low-power transmitter in addition to the high-power set. Operators at the central and receiving station may be sending out messages with the three transmitters simultaneously and other operators may receive from distant stations at the same time.



THE U. S. NAVY STATION AT PEKING, CHINA

Operated by the U. S. Marines located at the American Legation Compound which is within the famous 40-foot Tartar Wall. Two of the towers are atop the wall

The naval stations in the Pacific and in Alaska would be almost completely isolated from the United States were it not for the Army's cable and the Navy's radio service. The Army's cable has deteriorated considerably with age and consequently is frequently broken. At such times the radio service takes over all cable traffic in addition to its normal traffic and passes it on to stations situated along our Pacific Coast. In the Pacific, reliance is also placed on a single cable and when this fails, the only remaining medium of communication is radio. There is no connection with American Samoa except by radio but entirely satisfactory service is maintained between Tutuila and Pearl Harbor over the Navy's radio circuit, about 2,000 words being exchanged daily.

The Navy's transpacific high-power radio circuit may be said to extend into China and temporarily at least, into Siberia. A station of 30-KW power has been established within the Peking Legation Compound, surrounded by the 40-foot-high Tartar Wall, which encloses the American Legation, to prevent the American Minister from becoming isolated from the outside world when internal disorders are in progress in China. The ordinary communication facilities in China are unreliable under normal conditions and the service is frequently interrupted altogether when disorders are in progress. The Navy's radio station at Peking has afforded the only medium of communication on more than one occasion, not only for the American Minister, but also for the other foreign diplomats in Peking. The Peking station is operated by members of the Marine detachment guarding the American Legation. This station exchanges communications with the high-power station at Cavite, with the flagship of the Asiatic Fleet, with vessels of the Yang Tse Patrol and with the station at Vladivostok.

The Navy took over from the Russian Government the then incompleted radio station at Vladivostok as a result of the dispatch of American troops to Siberia during the war. This station has since been operated by Naval radio operators under the direction of the Commander-in-Chief of the Asiatic Fleet, and communicates with Cavite, Peking, and Naval and merchant vessels in Asiatic waters. The existing naval radio circuit extends eastward from Vladivostok and Peking through the Philippines, Guam, the Hawaiian Islands, American Samoa, to San Francisco, thence northward along the Pacific Coast to Puget Sound, Washington, and to Alaska; from San Francisco, southward to the Isthmian Canal Zone; from San Francisco through San Diego and across the continent to Washington; from Washington along the Atlantic Coast, the Gulf of Mexico and along the Great Lakes; from Washington southward to the Isthmian Canal Zone and the West Indies; and again from Washington across the Atlantic where contact is made with stations in European countries including the 1,000-KW station established by the Navy at Croix d' Hens, near Bordeaux, France to insure contact with our Expeditionary Forces in the event of the cutting of the transatlantic cables by submarines during the war.

The fact that the aggregate cost of the six successful naval high-power stations was within $1,500,000 is worthy of considerable reflection on the part of commercial companies engaged in building radio stations during the period 1914 to 1917.

The development of the Navy's high-power radio system cannot fairly be reviewed without paying tribute to Rear-Admiral R. S. Griffin, U. S. Navy, now retired, who, as engineer-in-chief of the Navy, was responsible for the building up of the naval radio service during his term as chief of the Bureau of Engineering from 1913 to 1921.

# One Vessel that Radio Might Have Saved

## By ORTHERUS GORDON

HOW long will it be before small ship owners will realize that a wireless outfit placed on their sloops and schooners may pay for itself hundreds of times over, on the first voyage? Day after day they are confronted with evidence that ought to convince them of its value, yet they continue to send their barges, their tugs, and their sailing craft down coast without proper means of calling for help should they suddenly need it.

A striking example of what radio might have done toward the saving of property for at least one merchant came to my attention with the sinking of the three-masted schooner *Tarok*, a year and a half ago. At that time, I was on board a large oil tanker going south in ballast. We had experienced rough weather from Cape Hatteras down and learned from passing ships that conditions farther south had been rough and unsettled for some days. The second morning below Hatteras we sighted a small black object one point off the port bow and soon made it out to be a small boat. As we approached it, we saw that there were five people aboard, and that one of them was waving a red tablecloth from the end of a spar. Coming alongside, we hauled them aboard—they were too weak to climb—hoisted their boat clear of the water, and made it fast alongside our port lifeboat. Then, while we continued our journey, we heard the story of the *Tarok*.

Her captain was as bitter as he was weary. He had recommended a thorough overhauling and a spell in dry-dock for his vessel. He had also wanted radio, if nothing more than a small spark transmitter to be run from a storage battery, and a crystal receiving set with which to set his chronometers occasionally, from the Arlington or Key West time signals. He had tried for these, but without success. The owners said the ship didn't need the first thing, and that he didn't need the second. They had told him it was absurd to equip with wireless a vessel that didn't go more than one hundred