161

~~CONFIDENTIAL~~

Section 3

Envelop 7

Year 1907.

No. 79

Author Russel, Major Edgar, Signal Corps, U.S.A.

Contents Wireless Telegraphy or Land. Paper read before the Naval War College, Newport, R. I., September 20, 1907.

To be returned

THIS PAPER IS CONFIDENTIAL. It must be returned to the President of the U. S. Naval War College by the officer to whom it is issued. If returned by mail, the paper must be enclosed securely in a sealed envelope, and sent by registered mail.

Radio-telegraphy.

LAND WIRELESS TELEGRAPHY.

In presenting this paper on land wireless telegraphy, I am doubtless dealing with subject matter much of which is already very familiar to you. The Navy has so energetically and successfully followed up wireless telegraph studies and installations that the principles involved and the construction of apparatus are matters of common knowledge among officers of the Navy. In the shore stations lining the coasts of the United States and our insular possessions, the Navy has given us a number of excellent examples of successful land wireless as well as marine wireless installations. The stations, the commercial ones, and those of the Army would all be available as parts of the military wireless telegraph system in war.

I shall not take up time going into the general history of the subject, or in comparisons of so-called systems of wireless telegraphy, as these are treated in extenso in all works upon the subject, and any attempt at description of the apparatus in general would be far beyond the limits of my time and your patience.

No one doubts the necessity of extensive military lines of information. Every theater of war will be ribbed with telegraph and telephone lines of all kinds, and wireless stations of every variety will unquestionably be considered a necessity. The great commercial systems of telegraphy and telephony in any civilized country will of course play a prominent part in these communications. As the Army

advances in the field, it will be followed by telegraph lines, strongly put up, and permanent, or semi-permanent in character. With such systems this paper does not propose to deal, as it is largely the mobile army with which we are concerned, the character of whose communications must differ widely from those which serve the people in time of peace.

The overpowering importance of adequate means of communication in war has only recently appealed to the commanders of the armies of the world. It has been said by a distinguished English military authority, "There is no salvation for an army, however, brave, however well trained to fight, which on the field of battle has to trust to the blind and semi-independent work of isolated units, if it is opposed by the combined force of an equally capable army acting as a whole under the well informed guidance of its supreme leader."

Major Swift, U. S. Cavalry, says in his work on "Field Orders, Messages and Reports",—

> "The commander must therefore be kept continually informed by messages from the troops engaged. This was so persistently ignored during the Civil War that General Grant concluded that it was impossible to secure information in the ordinary way, so he was in the habit of sending staff officers with details of orderlies to important points with orders to keep him informed. Napoleon kept a number of his best young generals at his headquarters for similar duties, and each was provided with a dozen horses."

General MacArthur, in one of his reports from the Philippines, has stated that he considered a force of 60,000 men with a thorough system of electrical communications well maintained, as efficient in the Islands as 150,000 men without this assistance.

The Russo-Japanese war has afforded military experts ample opportunity to study the advanatges of a well organized and extensively used system of lines of information. All our attaches have mentioned in their reports this feature, especially with the Japanese, as one of the marked advances in the art of war.

That a proper appreciation of its importance has been lacking in the armies of the world is shown by the fact that in all nations except the United States transmission of intelligence in the field has heretofore been designated and remains as one of the minor duties of the engineering forces of their armies. The United States alone has a corps,-- the Signal Corps,-- which is charged especially with this work.

The Signal Corps began experiments with disruptive spark wireless telegraphy in 1899, when an experimental station was put up at Governor's Island. The first experiments were between Fire Island and Fire Island lightship. It is stated that ranges up to 12 miles were obtained with this first crude apparatus. In 1899 and 1900 a number of sets of wireless apparatus were made up and experimented with at Washington and various points. The demands of the Philippine and Alaskan service on the small Signal Corps became so heavy that little more was attempted until the Artillery and Naval Joint Maneuvers of 1902, when DeForest, Marconi and Fessenden sets were hastily installed at Fort Mansfield near New London, at Newport on Block Island, and on artillery tugs. As the Navy promptly

captured the Block Island station the first night of the maneuvers, further interesting scientific investigations there by the Army were abruptly brought to a close. The crudity of the apparatus and the inexperience of the personnel at other points prevented more than a limited employment of wireless telegraphy. Marked instances of its utility, however, were seen on two occasions when the Artillery scout boat with wireless apparatus notified Fort Mansfield from a distance of 20 miles that the fleet was approaching. In these few instances of usefulness its possibilities were so marked that the scheme then originated of having a wireless station in each coast artillery district. This will presently be referred to.

The experiences of the three years previous to 1902 having shown the futility of maintaining cable communication across Norton Sound between Nome and St. Michael, Alaska, and a land line being impracticable, it was decided to attempt wireless communication across the 120 mile space. The line from St. Michael to Nome is the final stretch in the Alaskan land line and cable system, which has grown up so quietly that it is probable few outside of those immediately concerned know of its existence. Beginning at St. Michael, the land line runs up the Yukon to Fort Gibbon; from there up the Tanana River to a point beyond the present thriving town of Fairbanks, and then across the divide to the Copper River, ending at Valdez, on the southern coast of Alaska, in all a distance of 1200 miles. Beginning at this point, a submarine cable goes to Sitka, 600 miles distant, and from Sitka the cable

extends to Seattle, Washington, 1100 miles. Branch cables go off, one from Sitka, which brings Skagway, Juneau, Wrangel and Ketchikan into communication, while from Valdez a branch cable goes to Seward. This system includes about 2400 miles of cable.

In the efforts to establish communication between St. Michael and Nome, three of the existing wireless companies, in the spring of 1902, were invited to bid on installing stations at these points, and it was thought advisable to supplement the land lines through the Arctic wilderness as well, so bids were asked for two stations at interior points of Alaska. After a year's efforts nothing further was accomplished than the erection of a mast at Fort Gibbon on the middle Yukon and the placing of a few timbers on the beach at St. Michael. The Chief Signal Officer in the spring of 1903, despairing of results from commercial sources, began the construction and purchase of the component parts of the wireless sets and the erection of stations and masts.

By the close of the season the stations and masts were completed, and had it not been for the wrecking of a ship which lost much necessary material, there is no doubt successful results would have been obtained by October, 1903. Meantime experimental stations of 3 K. W. power were put up at Forts Schuyler and H. G. Wright on Long Island Sound, at a distance of 110 miles, and in the autumn of 1903 communication was established and maintained throughout the winter and

spring of 1904. The apparatus was largely the same as is now employed in stations of that size.

Complete supplies having been forwarded to St. Michael and the Nome wireless stations, they were carried to completion and communication was opened in August 1904.

The equipment at each station consists of a 6 H. P. Fairbanks-Morse gasoline engine, a 3 K. W. alternating generator giving 500 volts, an oil transformer and necessary batteries of Leyden jars, keys, measuring instruments and switches. The receiving sets used are of the electrolytic type with head telephones. The aerial system consists of from 2 to 6 rubber insulated wires leading to a harp suspended from the horizontal wire rope connecting the tops of two masts 200 feet high and 200 feet apart. Instead of a ground connection a "counterpoise" is used, consisting of several hundred square feet of galvanized iron wire mesh suspended a few feet from the ground on insulating posts. As far as I can learn this was the first extensive test of the counterpoise system. These stations have had a remarkable record in their practically uninterrupted operation since they opened three years ago. They transact the entire telegraphic business between the enterprising town of Nome and the outside world, through the Army land lines and cables extending to Seattle. They average several thousand words per day and have no errors charged against them, although many of the commercial messages are sent in intricate code. The average rate of transmission is stated to be 20 words per minute, although it may go as

high as 35 words per minute. The distance covered is not remarkable, but the steady transaction of a large volume of business for such a length of time is, it is believed, unprecedented. It appears all the more praiseworthy in the light of a recent statement by one of our prominent scientific writers, that 100 miles is considered a good general performance between short stations and ships equipped with the latest and best apparatus. The establishment of these stations in the far north in a remarkably short time under great physical difficulties illustrates the readiness of our officers and men to meet novel and difficult conditions.

Meantime it may be mentioned that in 1903 the Signal Corps made experiments with two Siemens & Halske portable wireless sets of the same pattern used in the German maneuvers of 1902. These proved entirely too cumbersome, complicated and unreliable for field use, and succeeded in attaining only moderate distances under the expert sent by the company.

The next two stations of importance were put in operation at Zamboanga and Jolo in the Philippines. Zamboanga is at the end of the military cable system from Manila. These are also 3 K. W. stations, the gasoline engines, dynamos and transformers being in all respects the same as those used in Alaska. The fitting up of the stations is different from those is Alaska, the receiving sets and subsidiary apparatus being composite, as the result of purchasing from many sources

and the manufacture of much of the apparatus by ourselves. The masts not proving sufficient, square wooden frame work towers about 200 feet high were erected at each station. The aerial wiring consists of rubber insulated cable core, this being favored by Captain Wildman in his Alaskan experiments. The difficulties introduced by tropical conditions have been well shown in the troubles of these stations. The soggy condition of the atmosphere so affects insulation that there are frequent displays of wireworks when the station is sending. Besides the records show many periods when "static" (atmospheric electrical troubles) are so bad as to keep the station from working. In Alaska this trouble seldom occurs.

In the summer of 1906 the growing needs of the Coast Artillery districts for wireless stations, both as part of their general communication system and for directing tugs when towing targets, as well as the necessity for wireless sets on the transports, caused the Signal Corps to take up seriously the question of designing these sets. Much of the commercial wireless apparatus offered was radically deficient and weak in its electrical engineering and mechanical features, or if suitable, the prices asked were exorbitant in the highest degree. Besides, there was great uncertainty in time of supply, especially when made abroad. Furthermore, there were difficulties in convincing the companies that we knew what we wished. The design was accordingly taken up by the office at Washington, in the Signal Corps laboratory.

The outcome of this was the design of (1) a three K. W. set either for transports or shore stations, (2) a one K. W. set either transportable in a single wagon, or for station use, and finally, owing to sudden needs developing in Cuba, the design of the field set suitable for cart, wagon, or pack transportation.

The 3 K. W. set consists of a handsome desk with all the light apparatus such as receiving set, key, switches, and measuring instruments mounted on the desk and on a marble panel extending up from the back. It resembles very much a telephone wire chief's desk, from which it was modeled. On wing extensions of the desk are mounted a solenoid oil break key and an enclosed fan-cooled spark gap. In the adjacent power room there is either an engine driven alternating dynamo of 133 cycles or it may be a motor dynamo. If the latter, there is an automatic starting panel controlled by button switches at the desk. The transformers may be either open or closed core. Near the desk stands a strong glass plate condenser made up very compactly. The Linking coil, of copper tubing, is usually placed on the wall or ceiling near the desk. It would be tedious to go into the many special features that have been introduced at all points. The aim has been to let nothing but the best workmanship and material go into any part, and the results seem to justify the care. Furthermore, it is pleasant to note that the expense has been moderate. The first of these sets was installed on the

Transport "Logan", and in its initial trip from San Francisco was carried by the Mare Island station 700 miles out. The North Head, Washington, Naval station has recently picked up another of the transports when 200 miles west of San Francisco.

One of these 3 K. W. sets has recently been sent and installed at Fort Wood, N. Y. Harbor, for instruction purposes. It is one of the numerous centers of electromagnetic wave distributors that keep up such a remarkable etherial disturbance in the vicinity of New York.

There have been established this summer at Fort Monroe, Va., and Fort Totten, New York, 1 K. W. sets for Coast Artillery use together with the small wireless equipment for target towing tugs, and there will soon be similar equipments at Fort Hancock, N. Y., Fort H. G. Wright on Fisher's Island, Fort Andrews Boston, Fort Levett, Portland, Maine, and Fort Worden, Puget Sound. The typical arrangement must of course be modified to suit local electrical power conditions, but in general the 1 K. W. Coast Artillery sets will have as sources of power 1 K. W. 133 cycle alternating dynamos, usually electrically driven. The open core transformers will be used generally, as it is thought more sharply marked oscillatory discharges are obtained from them. A desk and panel arrangement with all instruments neatly mounted thereon will be placed in the operating room, and the glass plate condenser and linking coil will be within easy reach. No solenoid switch will be needed, a simple oil-break key sufficing.

The typical aerial system will consist of an umbrella of 8 phosphor bronze wires each 100 feet long extending from the top of a 100 foot mast. From these, 8 wires extend down to the house. The Engineers propose to build at artillery posts a wireless house 1-1/2 stories high, with power, operating and sleeping rooms. On top of the house is a small platform for visual signal purposes, and it is proposed to put Ardois signals on the lower part of the wireless mast, while a halliard will be provided to run up code flags. Acetylene lanterns will be used in addition to the Ardois for night signaling. The signal detachments will always be on the alert for the reception of signals including wireless, and thus keep a lookout for ships of adjacent shore stations very much as is done from the bridge of a battleship.

This is all in line with the cooperation provided for already in naval regulations and probably soon to be in Army regulations as well.

The power is kept down to 1 K. W. since it is necessary to avoid interfering with the Navy as much as possible. Another important use will be that in connection with the coast defense scout boats in time of war. Of course these stations will be the centers for wireless communication with the Naval boats cooperating with the land forces in the defense. To provide the tug for towing targets with suitable apparatus for keeping in touch with the shore artillery wireless station, one of our small field sets is used, with a simple aerial wire arrangement aloft. This field set is

operated with storage batteries as presently described. Several sets have already been furnished for this purpose, and target practice is said to go off smoothly and quickly instead of being characterized, as formerly, with aggravating errors and delays. As targets are frequently out five miles or more, the difficulty of visual signaling is evident. When target practice is carried on from a post in the district other than that where the wireless station is located, the cable and telephone connections enable them to communicate with the wireless station, which then passes the message to the tug.

The call for extension of communications in Alaska to outlying towns and mining camps has caused provision of several 1 K. W. sets for that purpose. At present there are being put up at Fairbanks in Central Alaska, and Circle City near the Arctic Circle on the Yukon, 1 K. W. wireless sets very similar in operating arrangements to the artillery sets. The power equipment consists of a 2 cylinder Curtis gasoline engine mounted on a base with the 1 K. W. dynamo. The Carnegie Company of Pittsburg made two square steel towers 180 feet high for these stations, which can easily be put up. They stand on concrete piers, the square base being about 27 feet on the side. The problem of insulating these twoers is believed to have been solved by bolting the foot plate of each corner on a crib work of creosoted 12" timbers all well coated with insulating paint, bolted together, each under a galvanized iron housing to keep the timber dry. It is proposed to

experiment, using the tower as part of the antenna system similar to that of the Telefunken Nauen Station, and also to try it with the aerial wiring insulated from the tower. The top of the antenna will expand either into a long umbrella form, or be carried far out and guyed in one direction as in the Navy "flat top" aerials. The season in which work can be done is so short and the difficulties in the time allowed seem so great, that it will be attempted to work over the 140 miles across mountainous country with the 1 K. W. set, believing that with our large aerial system we can make it successful. If not, the 3 K. W. set can be installed next year.

The impossibility of securing material this year in time for the short open season on the Yukon prevented the Signal Corps from installing a 10 K. W. station at Fort Gibbon, about the middle part of Alaska. Next year also it is proposed to strengthen the St. Michael or Nome station so it may communicate direct with this Fort Gibbon station. The Navy is already putting up a 20 K. W. station at Sitka, and it is understood proposes next year to erect a similar one at Valdez on the Alaskan coast 500 miles northwest. This latter station if about 350 miles from Fort Gibbon. With these stations the following wireless chain from Nome to the United States will then exist.

Nome-Fort Gibbon.....400 miles
Fort Gibbon-Valdez.....350 miles
Valdez-Sitka.....500 miles
Sitka-Cape Flattery.....750 miles.

If these prove operative, they would serve as a valuable auxiliary to the present military land line and cable system, in case of interruption of the latter. This is likely to occur at any time with the single cable existing. In view of the satisfactory performance of existing Naval Pacific coast stations, it is reasonable to expect successful operation of the 10 and 20 K. W. stations across the spaces intervening. The climate of the northern Pacific and Alaska appears peculiarly favorable for long distance operation of wireless. I have no theories to advance on the subject, and only record the experience of the Navy and Signal Corps, in successful transmission of messages over much longer average distances than elsewhere.

There is now being installed a 3 K. W. wireless set at Fort Omaha, Nebraska, this to be one point of the triangular system with Fort Leavenworth and Fort Riley, Kansas. These stations are between 110 and 150 miles apart. The Fort Omaha station will have the regular 3 K. W. desk and panel equipped with the usual instruments. Commercial alternating power at 110 volts and 60 cycles will be used directly in the transformer, to be stepped up to the usual 25000 volts.

A neat and roomy wireless building, patterned very much after those of the Artillery stations, will be put up, and a 4 side Carnegie steel tower and antenna erected and insulated

in the same way as the Alaskan towers just described. At Fort Leavenworth and Fort Riley the stations are to be portable. The 1 K. W. size will be used, of the Signal Corps pattern known as "Field Wireless Set, 1 K. W.--Wagon." This consists of the Curtis gasoline engine and the dynamo on a base, enclosed by a galvanized pipe railing which supports the 3 gallon gasoline tank, and all necessary fittings. The whole weighs about 500 lbs., and is of such dimensions as make it possible to go easily into a wagon. The engine is belted to the dynamo which being 6 pole and 133 cycle runs at 2600 R.P.M. The engine runs about 1400 and has a fan on its shaft for cooling the cylinders. The operating outfit generally, except the open core transformer, is enclosed in a chest. Some of the features of the chest which may be mentioned are the compact and robust measuring instruments, the micanite plate Leyden condenser and the simple key and receiving set. The chest will probably weigh complete not over 100 lbs. The transformer weighs about 180 lbs. This and the chest are of convenient dimensions for putting into a wagon. In fact, the whole equipment will go into one wagon.

The aerial system has not yet been definitely worked out. In its experimental form it consists of ten light I beams, each ten feet long, capable of being easily bolted together. These are held vertically and successively raised with light shears, the lower one being bolted on below. Guys are attached and manned as this metal mast is raised. Finally an insulating section is introduced under the mast. For this an umbrella

form of antenna is contemplated. It is proposed also to have a light railed platform at the top which may be utilized as an observation station by one man who can be raised to it by a rope and boatswain's chair. This whole set is necessarily a wagon equipment and is intended to accompany the Division Headquarters.

It may take an hour or so to erect and guy the mast properly, and put the power and receving sets in working order. But when it is completed it is reasonable to hope that a 100 mile radius may be secured. A light tubular steel mast has also been ordered as a pattern possibly better fitted for this purpose.

Orders have been given for the purchase of material for another form of portable station, namely, an automobile fitted out with a 1 K. W. wireless equipment, and a portable mast and antenna. It is proposed to have a strong automobile of about 40 horse power with long chassis and full limousine top. In this will be placed a 1 K. W. alternating dynamo, transformer, micanite plate condenser, linking coil, and a switchboard and desk equipment very similar to the regular 1 K. W. station. The auto engines will, in addition to usual gear, be so arranged that they may be thrown by a single movement to the special clutch for driving the dynamo.

The details for the portable mast and antenna have not been settled. It is likely, however, that a jointed mast with sliding sections will be so arranged that it can be erected

at the rear of the automobile, the men steadying with the guys as it is run up. Of course the mast will be as high as practicable, probably between 80 and 100 feet. This is the only one of the sets which is yet in an entirely incomplete condition, but as it is already settled that this kind of equipment will be tested the outline of it may prove interesting.

The last set of the series, the "Field Wireless Set--Pack", as it is called, is the one upon which most work and thought has been expended. When the preparations began a year ago to send the expedition to Cuba, the Signal Office, believing that land operations were impending where a hostile population and unfavorable terrain would make the maintenance of wire lines difficult or impossible in many places, strained every effort to procure portable wireless sets to fit the light transportation which would probably be the only kind generally available. Some wireless firms in this country had in the previous summer offered to submit suitable sets of this kind, but only one attempted it. His set was by no means truly portable. The best that could be said of it was that it could be taken into a number of parts, each moderate in weight, but not at all suited for rough field transportation. So when emergency orders were placed about Sept. 1, 1906, for four sets from two firms in this country, and an order for two sets from one abroad, it was felt that the prospect of getting even fairly suitable apparatus was small, and in every instance the prices were exorbitant and the times of delivery

unsatisfactory. Consequently the design of sets was taken up by the Signal Office with all possible speed. Our fears of the apparatus furnished being unsuitable were soon realized. Not only was much of it faulty in general electrical design, but it was weakly and poorly put together, especially for the rough handling of field service. Besides, it was unnecessarily bulky and heavy and was complicated in its operation and assembling. Two of the sets furnished were well made and portable, but the generator was limited to about 40 watts, which is considered unnecessarily small even for a field set. The first four Signal Corps sets were not completed until November. We were compelled to put induction coils and other apparatus into them which were not satisfactory, and the separation of the set into two chests was not the best design. By December, 1906, the pattern at present issued was virtually settled. Many questions, some conflicting, of compactness, simplicity, strength and moderate weight had to be considered. All parts except the current generating apparatus and portable mast equipment are assembled in a chest of three ply "Leatheroid", which experience has demonstrated is a strong and durable material. This chest is two inches longer than the Quartermaster's standard pack trunk or chest, conforming to that pattern in all other dimensions. It is painted the standard service olive drab, and looks like a rather high and somewhat short steamer trunk. It is provided with trunk hinges, lock and fittings, iron handles on the end,

and short wooden supports on the bottom to keep it off the wet ground and furnish holdfasts when placed on the pack. When the top is thrown up it is seen that the inside of the lid is fitted with an 8 glass tube Leyden condenser, a flat spiral linking coil (sending inductance), a socket for the antenna plug, and a ground post. Flexible rubber covered wires from the closed and open oscillating circuits, with clips on the ends, furnish the means of making various connections with metal projections from points of the linking coil. In the trunk is seen the interrupter on the right, the key to the right and front conveniently placed, the primary condenser under the key, and the induction in the center and rear. A rotary switch with its multiple points provides changes for all circuits at one motion when the antenna plug is inserted for receiving, or pulled out and put in the socket in the lid when sending. The receiving set is at the left and comprises, on one rubber base, the switch for the small receiving mica condenser, the battery switch, the adjustable petentiometer, and the electrolytic receiver at the rear. This latter consists of a metal support for the platinum point holder, and a hard rubber cup containing the bottle with lower platinum electrode. This cup is removable, somewhat like a lamp socket. A silicon receiver is also provided as an alternative receiving device. The receiving tuning coil is also on the left. This is provided with two sliding roller contacts. The proper cords, clips, spare parts and tools

and head receiver go in a space on the right, together with a miniature lamp in a hard rubber holder which is temporarily introduced in the antenna circuit, and indicates by its maximum glow when resonance is attained between the closed and open oscillating circuits. The induction coils, primary condensers, and many small parts are all made by the Signal Corps. No firm in this country seemed willing or able to make up induction coils conforming exactly to our requirements. As it is, our coils while of moderate dimensions, give a surprising output and appear secure against mechanical or electrical breakdown. The interrupter seems a necessary evil, although with some experience the present pattern has given little trouble.

The proper source of electrical power is a difficult matter to decide. For best and smoothest operations there is nothing like 8 good cells of storage battery to give the 16 volts and 8 amperes needed. A very compact and portable form of storage battery, consisting of 2 groups of 4 cells each in strong sealed cases liking the sparking batteries in automobiles, gives good service. These have a capacity of forty-five ampere hours, which would run the wireless set for about 10 hours steadily, and would ordinarily operate it for at least four or five days. But there would come times when the gasoline field charging outfit furnished would not be available for recharging the storage batteries. This gasoline charging outfit can itself run the wireless station, the little direct connected engine and dynamo giving proper

voltage and current for this purpose. This outfit is compactly assembled for wagon or cart transportation, and weighs about 300 lbs.

A promising electric power equipment for field sets is a hand driven dynamo. Several of these have been tried. The dynamo is mounted on a collapsible iron stand about elbow height, with two handles projecting on opposite sides. Two men working rather vigorously can develop the 16 volts and 8 amperes (128 watts) required when the key is closed, and when the pauses are considered, can work it for some time. The latest pattern of this when packed in the cases weighs 130 lbs,- two cases of 65 lbs. each.

In some of the sets used in Cuba a small pedal driven dynamo is operated by a man mounted on a frame somewhat like that of a bicycle. But the power of the man in this case is limited to about 50 watts output, so it is not suitable for field sets equal in power to those of the Signal Corps.

One of the most troublesome problems in the field set has been to provide suitable means of supporting the antenna. Two fairly successful means of doing this are the light jointed mast and the folding kite.

The jointed mast consists of 10 sections each 6 feet long, octagonal, and about 1-1/2" diameter. Copper strips 1" wide are tacked the full length of the section and secured to the aluminum or McAdamite metal collars and sockets at the ends. These strips thus joined constitute the vertical

wire. The upper three of the sections are pine, the middle five ash, and the lower two hickory, thus distributing weight and strength in the best way. The lower section, without a strip, is the insulating section. It is found necessary with this mast to have two lower sets of guys of four ropes each, in addition to the upper guys, which incidentally support the umbrella aerial of eight phosphor bronze stranded wires radiating from the top of the mast. These umbrella wires are each fifty feet long. The mast is raised by two men lifting it, while another puts on the lower sections successively. Meantime the men at the guys steady the mast as it goes up, and peg down the guys when complete. From the bottom section of the mast radiate 6 phosphor bronze wires secured to insulators on light lances 7 feet high. This lower set of wires is electrically connected and constitute the "counterpoise" used on the sending circuit instead of a ground. This whole mast system and counterpoise has been erected in 15 minutes by a squad with a little drill, and with more experience the time could probably be cut down.

The other means of supporting the antenna is the folding kite. This requires three sticks, and any strong light fabric, preferably silk, is used. The horizontal stick is removable and the whole kite can be compactly rolled up. Two sizes of kites are used, respectively 6 and 7-1/2 feet in height. A multistrand phosphor bronze wire is used, the thousand feet

furnished with the kite weighing about 12 lbs. This is rolled up on a gun metal reel provided with a strong handle, brake and stop. The whole device has proved quite satisfactory and portable. The kite antenna has shown great adaptability for receiving long distances, although for sending it does not appear quite so efficient as the mast and umbrella antenna.

The counterpoise has been found superior to ground connection in a majority of cases. Whenever ground is thoroughly wet, and time permits many ground rods to be driven, it may be the ground connection is preferable; but for rapid work in the field it is believed that the counterpoise will serve the better purpose. The masts, sections, and counterpoise lances are made up in two bundles for packing, with canvas bags over the ends of each bundle. The guys and wires are wound on flat bobbins, and these with the guy pegs, the central counterpoise insulator, and two 4 lb. hammers for driving the pegs, are packed in a larger canvas bag. The mast sections and lances are lashed on each side of the pack mule and the large canvas bag on the back, the pack weighing about 200 lbs. The latest form of portable batteries or the hand dynamo in two packages go on another mule, this pack weighing about 130 lbs.

The wireless chest, weighing 150 lbs, goes on another mule. The whole equipment thus weighs 415 lbs., giving each mule such a light load that it is thought he would have no difficulty in keeping up with cavalry columns. In fact, Mr.

H. W. Daly, Chief Packmaster, Q. M. D., who planned the aparejos and devices attached thereto, for packing these wireless sets, is authority for the statement that after two days marching the pack train can overtake, and in many instances distance, the average cavalry command.

The varieties of wireless equipment described are thought to cover in general the needs of the military service. We have not considered the huge stations where great distances are proposed to be covered, such as the shore stations of the Navy. A word as to the role of these large permanent stations will, however, come in appropriately here. In Cuba at present the Signal Corps is engaged in fitting up for the Provisional Government 6 stations as follows:

Pinar del Rio, 5 K. W.
Havana, 20 K. W.
Santa Clara, 10 K. W.
Camaguey, 10 K. W.
Santiago de Cuba, 20 K. W.
Baracoa, 10 K. W.

These, with the powerful naval station at Guantanamo and the existing one on the Isle of Pines, form a chain of wireless communication which will insure our lines of information against a breakdown in case of destruction of land lines. This is a very likely contingency if there are general insurrectionary troubles. It has been found that within a radius of 100 miles one of our field pack sets can communicate with stations having these large aerials.

By spanning the territory with this chain of permanent stations it is seen that expeditionary forces anywhere in

Cuba can always communicate with these large stations and, if necessary, with each other, by repetition of messages. The military advantages of such a system are at once apparent, and suggest the proper procedure for securing our lines of information as we occupy an enemy's country.

The wireless sets described, with the exception of the 1 K. W. stations for Coast Artillery districts, are proposed to be used somewhat as follows: The 3 K. W. sets, while not strictly portable, can be put up in such parts that none need weigh over 800 lbs. This means they may be readily loaded and unloaded from vessels and transported in wagons. They would thus be available for use at the bases, at large depots, and at Corps Headquarters when reached by wagon or railroad. Sectional masts could be taken along and put up, and under favorable conditions in 24 or 48 hours the 3 K. W. set could be in use. Its radius of operation with sets of equal size would probably be over 200 miles. The 1 K. W. field set, having everything already connected up, is the first of the really portable ones, and on this and the smaller set we shall probably rely to furnish most of the wireless service for our mobile army.

The only element upon which data is lacking is the jointed steel mast, and we are confident that the one recently purchased, or one we can devise, will be capable of erection within an hour. It is certain that all other parts of the station can be made ready well within this time. This may be

called the division headquarters set. With it the division headquarters could keep in touch with corps headquarters or adjacent division headquarters probably within 100 miles. If the automobile 1 K. W. wireless set turns out as we hope, this will be the readiest means of keeping up the division headquarters line of information since it carries within one unit the entire wireless equipment, and furnishes its own transportation. But the question of fair roads will always be uppermost in the mind of the military automobilist, as well as any others, and we shall have to regard this facinating style of wireless station as auxiliary for the present.

Coming to the "Field Wireless Set-Pack", we reach the lightest of the portable sets. It is the one which, in some of its forms, will probably constitute our main reliance for wireless communications in our mobile army. As in the case cited of Cuban land stations, the operation of these sets anywhere within 75 miles of the corps or division headquarters will probably open communication, and experience in Cuba leads us to believe they can be generally relied upon for intercommunication within 20 miles. The power this puts into the hands of detached parties and reconnoitreing cavalry will no doubt cause important changes in the rules laid down in security and information and in minor tactics. It is well to note, however, that recent advances in military telegraphy with field wire lines and buzzers have made the relative advantages of wireless over wire lines appear less.

The question has frequently been asked, what effect would interference have upon the practical operation of wireless sets in the field? It is not believed that this will

prove so serious a matter as might be thought upon first consideration. The operating radius of the sets with moderate heights of antenna is not great, and only small sets in this radius, say twenty miles, would in general interfere. These would,in many cases, be under one command, and precedence in matters of operation could be determined by general orders, just as the different stations on a military telegraph line are assigned the wire in order of precedence of messages which may be presented for transmission. It has been found that these small sets tune quite well, even with the present simple circuits, and it would be entirely possible to assign different wave lengths to certain stations. In case of interference by the enemy's wireless stations, it will at once be apparent that this matter is entirely reciprocal, and that if he interferes with us we can certainly do the same with him. It might even be said that this feature alone would warrant the taking of comparatively powerful generating apparatus into the field where the confusion of the enemy's signals might be just as important as the sending of our own.

In view of the astonishing results which have been achieved with even the smaller wireless sets, the military student is apt hastily to conclude that it should replace all field telegraphs depending upon wires for their operation. He will perhaps have in mind the telegraph trains of old with their huge lance trucks, their wire wagons with tons of galvanized wire, and their battery wagons, when lines were laboriously

built and no less laboriously recovered to be used elsewhere. These lines depending upon remaining aloft, were easily rendered inoperative either through accident or design. To understand the role which wireless apparatus is to play on the modern battlefield, a brief review of the present development of modern field telegraphs, field wire, and the means of handling hasty lines will make the matter clearer.

The standard field telegraph instrument now used in our army is the buzzer. This little vibratory or induction telegraph kit is one in which the main and local batteries, switchboard, key, and in fact the complete equipment of our old fashioned telegraph office is merged into a set contained in a little case which can be carried like a field glass. It has merited a certificate of success coming from extensive use in our Spanish and Filipino war, and has recently received the seal of approval from the Japanese, whose successful use of field lines of information is admittedly one of the strongest causes leading to their success. There are two types of buzzers used by the Signal Corps in connection with two kinds of wire. The first wire is a lightly insulated steel and copper strand weighing about 10 lbs. per mile, and the second the regular field wire of insulated steel strand and copper weighing 70 lbs. per mile. This latter wire is very strong and is simply paid out along the line of march and will bear such abuse that it may be said it can only be broken intentionally.

The small wire is handled by breast or hand reels, and may be paid out or taken up at rapid gaits. The field wire is in general best paid out or taken up by a reel cart. These carts can hold ten miles of the wire, and it can be paid out at a trot. The automatic reeling up apparatus will recover it almost as fast. A buzzer station can be established within a minute of the halt and telegraphy used at the rate of 30 words a minute. Or when the wire is in good condition the same instrument can be instantly converted into a field telephone. The capabilities of operation of the buzzer over poorly insulated and even broken lines are incredible to telegraphers unused to its operation. With such modern improvements as this in the hands of the military operator, it is well to consider thoroughly what this newcomer, the wireless, can do in place of the reliable portable, simple, compact buzzer, with its quickly laid lines so difficult to interrupt by accident.

The objections to the buzzer lines in military telegraphy are, first, bulkiness and weight of wire required (about 1 wagon load for every 25 miles of line); second, time required for laying lines; third, liability to interruption of lines. The advantages, generally, over the wireless telegraph are; first, greater speed in transmission, about 15 words wireless compared with 35 words buzzer per minute.

Second, greater secrecy; while the buzzer might be tapped, the messages from wireless are disseminated in all directions.

Third, in general the buzzer station can be opened more

quickly than the wireless station, although with storage battery power and kite antenna carried along the road, the wireless set may in some circumstances be put up as quickly.

Fourth, the greater simplicity of the buzzer and field wire is at present a telling point in their favor.

Fifth, the far greater reliability of operation of the buzzer, under present conditions of the wireless apparatus, is unquestionable.

These are only a few of the points of comparison which are suggested. But in the light of special cases which may arise, many of these considerations may be completely reversed.

For example, in comparing message transmission by a mounted orderly and electrical methods, when the message is under 10 words, the orderly excels all other means in distances under half a mile; and for messages over fifty words at distances less than a mile. His value may be said to depend on the length of the message and the distance it is to be carried.

In comparing field wireless with buzzer transmission, just such considerations will frequently determine relative excellence for the purpose. In camp, on the march, or deployed when in contact with the enemy, there are varieties of conditions which will require the utilization of all the resources which the telephone, wire telegraph, and wireless connections can furnish. In camp the telephone will be largely used for local communications, while temporary or semi-permanent wire lines will connect with the base and adjacent headquarters.

The wireless telegraph will no doubt be always ready to serve as an alternative in case the wire lines are destroyed. On the march the column will be immediately followed with field wire lines, to be succeeded by temporary or permanent pole lines in case of occupation of the country or great extension from the base. These also will be supplemented with wireless communications. In the case, however, of the advance over several parallel roads, the connection of these columns through the lines reaching back to the base may, on account of double liability to rupture, become precarious, and portable wireless sets will at once rise in importance as a means of maintaining communications. In the case of a flank march in hostile country, the wire lines are so exposed that their maintenance would probably be most difficult, and here again it is more than an auxiliary.

The cavlary screen has always been the ears and eyes of an army. With the great mobility of its units, it goes boldly into the enemy's country on the front and flanks of an advance, and by its ability to cut loose and make forays it can gather information of the greatest value. But having gathered it, the great problem has been to get it back to the general commanding in time to be of use.

The buzzer and field wire may in many cases serve the purpose, but the rapidity and freedom of movements may be hampered thereby. In this case particularly it appears the field wireless sets have a future in which they will

experience the greatest development. It gives a new impulse to the employment of cavalry, which will no doubt be greatly appreciated by that arm.

In the final application to be considered,- the combat,- the role of wireless telegraphy cannot be clearly foreseen. When troops are deployed and engaged, the lightning-like changes in situation and the ever shifting phases of the conflict will tax all our resources. It is certain that every movement must be followed with lines of information of some kind. It has been said that the day is past when the commanding general will be galloping about the field with an imposing staff. The modern battle picture is most clearly sketched in the reports of our attaches of the battles around Mukden, when we see Oyamo twelve miles in the rear of his lines, which extended over forty miles front, with his radiating tactical lines of information reaching to each army, corps, division, and even brigade, his map with colored markers before him, with which he quietly directed all the moves in this living war game. There was no hesitation, no delay, because he received constantly from numerous points along the front of his great army accurate reports of everything that was going on. It is not believed that with all the success the Japanese attained in the use of electrical lines of information, that they had as good apparatus, field wire, or resourceful men as we can now command.

Neither the Russians nor the Japanese appear to have

made use of field wireless communications. Some portable sets of the Marconi Company were sent to the Russians at the close of the war, but through hasty manufacture, or ignorance in utilizing them, they were never put into service.

The greatest activity in devising portable wireless apparatus abroad for field use appears to have prevailed in Germany. As early as 1897 experiments began, and it is interesting to note in connection with our experience that at first little faith was placed in field wireless communications by the German Army. In 1901, 1902 and 1903 it was tried out in the annual maneuvers apparently each year with increasing success. The Siemens-Halske apparatus was used in the first two years, and the combined German companies (Telefunken) apparatus in 1903 and apparently since.

The German field equipment in general is transported in pintle wagons, or carts similar to the ones furnished the American Navy and Signal Corps. The later type consists of three carts, each said to weigh not less than 1325 lbs. One of these carts carries the generating machinery, the second the sending and receiving apparatus, and the third small balloons with gas tubes for inflation, kites, etc., for raising the antenna. In the 1904 maneuvers it seems that 100 kilometers was the ordinary distance up to which the station operated. In the Southwestern Africa revolt the Germans seem to have made extensive use of portable wireless sets in 1904.

The three cart stations are said to have a guaranteed range

of 300 kilometers. The wireless telegraph organization in the German army is stated to be a detachment of 8 officers, 5 N. C. officers and 88 men. Forty horses are used.

With regard to France, I have no authentic information as to the use of wireless telegraph in the army. In England it appears the Lodge-Muirhead system has been made up in portable form for field use and has been tested, but there is no information available regarding results.

Italy being committed to the Marconi system, it is probable they use only sets furnished by that company. According to a recent daily paper, it appears that the Italian army made extensive use of field wireless sets in the maneuvers, which lasted from August 26 to September 3. This account states that the attacking army was entirely successful, due largely to the excellent use made of the wireless communications. It is stated that there was never a time when the whole line of the attacking army was not in instant communication with its commander. At intervals of twenty miles along his line he established these wireless stations. From these centers automobiles were used to carry orders to intervening points. It may be said that the American Army under similar conditions would probably have taken care of its local communications by the use of buzzer lines.

The Telefunken Company of Berlin, in addition to supplying material for the German Army, has been active in placing a number of their small field sets with other Governments.

Four of their sets were used successfully by our Signal Corps in Cuba during the past year for distances up to 23 miles.

A number of papers have recently been prepared by officers of the Signal Corps, in which comments have been made upon the auxiliary position which the wireless will occupy in field communications on account of interference, weather troubles, complexity and delicacy of the apparatus. It appears to me that it is too.early to assign such subordinate position to wireless apparatus. Looking at it broadly, the superiority of apparatus which requires no communicating wires is evident over that which does. It is true that it lacks secrecy and certainty of operation in its present forms. But with several promising experimental methods of directing the waves, and the rapid improvements we have been able to make in field wireless apparatus in one year, it appears very hopeful for the increasing use of wireless sets in the field and their replacement of wire lines before many years. When we consider that the first feeble beginning of wireless telegraphy were only ten years ago, the progress it has made is truly wonderful.

There is no dount that for the shorter lines connecting the smaller units, the buzzer and field telephone will continue to have a most useful field. The relative positions which these and wireless apparatus occupy will no doubt resemble those of wire telegraphy and telephony in general, each with its field in which the other cannot compete.

Having had some experience in using field wireless sets, I can quite understand the pessimistic views of those who first try them, since their wide departure from ordinary telegraphic appliances is such that they are certainly obstreperous in the hands of those unaccustomed to them. When instruction, practice and familiarity were possible the reports generally changed from hearty recommendations consigning them to the scrap heap, to enthusiastic endorsement for all field telegraphic purposes.

No doubt their true place lies somewhere near the mean between these two extremes.

It is now universally recognized that the day has past when the fortunes of war will depend solely upon bravery in combat and the individual excellence of any one part of the command. Success must be attained by binding all together and working as a harmonious whole. It has been said:

> "---War has its higher fields, and he who would move successfully in them must know more than to defend with shield and thrust with spear. In those fields the general finds his tasks, the greatest of which is the reduction of the many into one, and that one himself; the consumate captain is a fighting-man armed with an army."