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THE TECHNIQUE OF LIAISON IN BATTLE

EDITED AT THE ARMY WAR COLLEGE

JULY, 1917

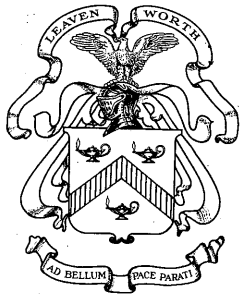
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WAR DEPARTMENT,
WASHINGTON, *July 30, 1917.*

The following "Notes on the Technique of Liaison During Battle" is published for the information of all concerned.

[062.22, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
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OFFICIAL:

H. P. McCAIN,
The Adjutant General.

16 JUN 1994

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
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BY ORDER OF THE SECRETARY OF WAR:

H. P. McCAIN,
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THE TECHNIQUE OF LIAISON DURING BATTLE.

INTRODUCTION.

The operations of October 24 and 25 and December 15 and 16 on the right bank of the Meuse proved that in the near future it would be possible to maneuver on the field of battle itself.[1]

To-day it is quite possible to transmit information from front to rear easily and quickly.

Equal progress might be made in the transmission of information from rear to front. In order to realize this aim, it is necessary to consider the means of liaison at hand, the improvements possible, and the new processes to be evolved in order to perfect the present methods.

The instructions of December 16, 1916, on liaison for troops of all arms reads (p. 23):

"All the methods given in the present instruction were tested under the most varying circumstances. Each one has at times given entire satisfaction, but none has been proven absolutely reliable."

Consequently:

Every means at one's disposal should be prepared and developed until each one is entirely self-sufficient.

As there is no room for improvisation, and as, during battle, the troops can only use those methods with which they are entirely familiar, they should be required to practice the regulation methods every day—or frequently, at any rate—even though only as part of their drill.

When one method fails the others should be tried successively and without intermission.

[1] It must be borne in mind that as the weather conditions during those four days were not always favorable the results obtained were all the more interesting.

Necessity is creative.

The changes in maneuvering since the war began have entailed profound modifications in the means of liaison formerly used. Information must reach the command quickly and safely [1] if a success is to be followed up or a move of the adversary blocked.

For the same reasons information should be carried rapidly and safely from the command posts to the first line. Experience proves that gaps exist in transmission in either direction. This difficulty must be overcome. The logical application of technical means, animate and inanimate agencies, visual, audible, and electric, will soon provide a satisfactory solution to this most important problem of warfare.

I. TECHNIQUE OF LIAISONS.

CHAPTER 1. ANIMATE AND INANIMATE AGENCIES.

1. Couriers [2] have always been the means of transmission most frequently used in past wars. He is the "intelligent" agent. The liaison is usually maintained by "relays of runners."

Relay posts are usually 150 to 300 meters (164 to 328 yards) apart.

This is often the only means of transmission capable of operating during a modern battle.

It is more efficient during an offensive than a defensive, and more rapid when going from the front to the rear. The morale of the soldier plays a great part in this respect.

In either case the runner may be struck before his mission is accomplished, which would cause temporary delay in transmitting the information.

The risks vary considerably, but important information will sometimes justify the use of a courier. If he escapes enemy shells or bullets, he may lose his way, which will also result in delay. Couriers unfamiliar with the sector have been known to wander around several hours before finally reaching their destination. A few hours of severe shelling will so completely transform the appearance of the locality as to cause confusion

[1] This information must remain secret even if it falls into the enemy's hands.

[2] If combat in the open is resumed, mounted couriers can carry out a certain number of liaisons between units.

and inimical delay.[1] The choice of courier is very important and should fall on men of courage and intelligence who, in spite of gaps in the relay, will insure the delivery of the information intrusted to them.

2. Aerial courier.

We will now consider the rôle of aircraft as liaison agencies—that is, as transmitters of written information and orders.[2]

Intelligence can be carried very quickly through the air, right up to echelons near the first line.

If the communication is to be carried from the rear to the front, the aviator drops it, weighted, during flight.[3]

The message is placed in a sheath with streamer attached, and a cartridge percussion fuse, which indicates its point of fall. It is thrown from a height of not more than 300 meters (328 yards), and the observers are usually able to aim it fairly close to its destination.

Aerial liaison can not be used at night or during unfavorable atmospheric conditions, such as fog, mist, storms, snow, etc., and therefore can not always be relied upon.

As aeroplanes can not land within the first lines, it is impossible to send information from the front to the rear unless it is possible to speak to the plane from the ground. The methods in use, which will be discussed later, are still very incomplete (lights, projectors, and panels), but will be completed later when aeroplanes are equipped with wireless telephone or telegraph receiving apparatus.[4]

During combat in the open aerial couriers would have a wider scope, as they could land fairly near the advanced positions and

---

[1] During the night of the 23d–24th of February, 1916, I was on my way from "Louvemont" to "Ornes" by way of "Les Chambrettes," and took over 15 minutes to find the fork in the road from Chambrette to Ornes and Chaumont, although I had traversed it innumerable times before; its appearance had been entirely changed since the attack.

[2] Other uses of aircraft for liaison will be mentioned later on. Its rôle has become so important as to be rightly called an organization inspired by the brains of the command, seeing and taking part in the battle.

[3] For more advanced echelons, colonels, battalion commanders, troops—the weighted message can not be used—the aviator will have to communicate directly either by means of visual or audible telegraph.

[4] The British Army has already adopted this method, and the German Army also, for defensive use. (See instructions of general commanding the Ve German Army, dated Dec. 1, 1916.)

thus insure rapid liaison between units at great distances and during extensive operations along an extended front.

3. Pigeons and other animals.

Pigeons are an excellent means of communication between the command and the first line (Fort de Vaux), but can seldom be used as a means of transmission from the rear to the front.

They sometimes lose their way, and the information falls into the hands of the enemy. A German pigeon caught October 23 showed the precarious position of the enemy on the right bank of the Meuse, and especially at Thiaumont.

Other animals have sometimes been used as liaison agents, but not very successfully.

Dogs, who are especially recommended for this purpose, are apt to be frightened by the shelling.

4. Message throwers.[1]

The most primitive thrower is a stone around which the message is wrapped.

The bow and arrow is a highly efficient means of attaining this end and has often been used in the colonies. It is accurate, noiseless, and does not attract the attention of the enemy, but its range is limited to 80 to 100 meters (87.49 to 109.36 yards).

The use of the crossbow deserves more attention, since its range reaches 150 meters (164 yards). As the distance between the point of departure and strike is increased, its fall to earth should be signaled by some distinct light or smoke.

Rockets have been studied also. The Ruggieri firm invented a device mounted on a stick which will carry 700 meters (765.54 yards). The small metal box containing the message is fastened to the side of the device, and attention is attracted by the brilliant combustion of a certain aluminum composition during flight. When it strikes the ground another composition throws out a very bright light and profuse smoke. Its most serious drawback is the fact that it utterly lacks precision.[2]

Devices fired by rifle. Attempts have been made with tubes the size of an ordinary bullet and containing the message.[3] The fall is retarded by a spiral spring, and upon landing some sort of mechanism emits smoke. These rather delicate devices have not given conclusive results, and misfires have been numer-

[1] This method has not been used much during the present war, but its more extensive application can be predicted in the future.

[2] Although it was used with success on the Somme.

[3] Invented by Capt. Roux, ministry of inventions.

ous. In addition to which its small size made it hard to find in a field of tall grass or on muddy ground.

The proposition made by Capt. Naud is more interesting and the experiments gave satisfactory results.[1]

Its general form is that of a flanged grenade, with a range of about 300 to 400 meters (328 to 437 yards). A little practice will enable one to acquire pretty accurate aim. Upon striking the ground it gives off another bright light and a very dense and characteristic smoke.[2]

Under various circumstances the "Naud" thrower could render invaluable service. (Fort de Vaux.)

Another projectile is under consideration, which can be fired from a V. B. discharger, a parachute rocket, or sheath,[3] which might also render efficient services.

In trench warfare it would be a satisfaction to be able to use the regular trench devices as message throwers.

Projectiles with parachutes have been constructed for the Brandt air-gun, which has reached a range of 1,200 to 1,300 meters (1,312.35 to 1,421.63 yards). The tests were very satisfactory, and it is to be hoped that they will be adopted for service.

In open warfare 37-millimeter (1.4-inch) guns could be used as message throwers, and the study of a suitable projectile should not present grave difficulties.

5. Message carriers.

Sometimes small free balloons are used, but as their point of fall is uncertain they can only be used nowadays in a few extraordinary cases.

Occasionally messages have been placed in bottles or other containers and carried off by the current of canals or rivers.[4]

CHAPTER II. VISUAL.

The receiving and sending posts are fixed. The eye is the principal receiving organ.

1. Arm signals.

---

[1] The general headquarters have ordered the manufacture of a certain number.

[2] Its drawback is the same as that of the flanged grenades, which becomes useless if the handle which is inserted in the gun is out of shape. They require the greatest care in handling and transporting.

[3] It has become regulation to fire rockets by day or night from V. B. dischargers.

[4] Marines especially have made use of this method on several occasions.

Morse and other conventional signals are made by the arms alone or, more often, with flags or other similar objects. This method has rendered important services. During the Verdun battle, observers in aeroplanes were able to receive messages from the ground by this means.

2. Panels.[1]

Signaling by panels is so arranged as to enable correspondence with balloons and aeroplanes as well as occasionally with observing stations in the rear. Fixed panels are usually used as identification or locating panels. Their dimensions vary considerably.[2]

To obtain lightweight panels for the Infantry.

They are now made of oilcloth, white on one side and of a neutral tint on the other. Dimensions 50 by 40 centimeters (19.68 by 15.75 inches); they can be cleaned when muddy or dirty.[3]

The inconvenience attached to the fixed panel is that if the man who carries it is killed, it remains on the field of battle.[4]

For this reason adjustable and movable panels have been suggested.

Movable panels. Movable or adjustable panels have been suggested and tried. Regulation window shutter panels permit the instantaneous disclosure and covering of a white rectangle 1.50 by 2.80 meters (1.63 by 3.93 yards), made of strips of canvas lined with some material of a neutral color, one side stable and the other mobile.

By turning the shutter a sliding motion is obtained which folds and unfolds these strips, showing the white and neutral sides alternately.

Morse signals are thus possible between the ground and aeroplane. The British Army has also adopted a small window shutter panel of oilcloth of the same style (200 grammes (7.04 oz.)), only the white side showing at the desire of the carrier.

---

[1] The use of panels has become current during battle, and has become indispensable for the liaison between the ground and aircraft.

[2] See instructions for the liaison of troops of all arms, 1916.

[3] The Germans have panels which are white on one side and red on the other. On snowy days or chalky terrain only the red side is exposed to the aviator's view.

[4] Permanent panels may also be seen by the enemy. They should always be made more visible by motion.

Another suggestion was for washable oilcloth panels, white and neutral on the respective sides, which can be automatically closed by elastic bands fastened to the two opposite sides.[1]

An adjustable panel on the principle of a Japanese fan, the successive spreadings to be read and its automatic shutting to be insured by means of a closing spring.

An automatic rolling blind inclosed in a metal cylinder has been tried, large size 2 by 0.47 meter (2.187 by ½ yards), small size 0.64 by 0.30 (0.69 by 0.32 yards).

It has been possible to make Morse signals between earth and aircraft with the former, but the smaller was not adopted because it was heavier (700 grammes (1 lb., 8.64 oz.)) and more complicated than the panels described above.

Findlly M. Deffaim proposed the use of kites and detachable streamers for long distance signaling with movable panels.

The panels are made of stuff, small sails attached to holders like all kite tails, only these are equipped with a spring which makes the sail turn 90° and catch the wind as soon as the holders strike a plug which acts as a stop and is fastened to the thread a few yards from the lifting cells of the kite.

During the entire flight the panel is visible at a great distance; as soon as the plug is reached the panel descends rapidly and the signal can be repeated several times in quick succession.

The inventor proposes using panels of various colors. The model furnished by the inventor for the tests rose easily on a 3-meter (3.28-yards) wind.

3. Rockets.

Signaling devices have made great progress during the last war. Increase in numbers and variety in the methods of firing have been the object of special study. There are signals for day and night use. Rockets of various types.[2]

Rocket with stick: The ordinary rocket is divided in three parts—the part which propels, the filler which is attached to the head, and the stick which guides its course. In this way it is possible to vary the number of signals by attaching to the head with its stick the various types which have been prepared by the firework makers and adopted by the command.

The ordinary rocket is rather cumbersome and difficult to preserve in the chaotic condition of ground upon which battles

[1] An adjustable cylinder of large make is used for signaling from a balloon to the ground.

[2] See instruction on the liaison of troops of all arms, 1916.

are nowadays fought. White, red, and green star signals have been adopted[1]; also, "Chenilles"—bright circles of stars. These stars are held in the air by a parachute after the rocket has exploded. New devices are also used, especially dense red or yellow smoke or large "drapeaux" (1 by 2 meters (1.09 by 3.28 yards)) balls.[2]

The greatest drawback of a rocket is that it shows the enemy the point from which it was sent.

Formerly they were fired from a frame, but that has now been replaced by a simple light tube.

Cartridge signals.—Signals fired by the 25 and 35 millimeter (0.98 and 1.37-inch) (aviation) pistols have been greatly improved.

The V. B. discharger is used for discharging illuminating and other fireworks.

Signal cartridges are advantageous because of their small size.

Their transportation and preservation is easy[3] and their point of departure not revealed to the enemy. Attempts have been made to reproduce marine signals with cartridge signals for pistols and V. B. dischargers by means of parachutes, drapeaux, and lights.

In this way liaison would sometimes be possible between advanced echelons.[4]

Bengal lights.—These devices usually burn 30 seconds and can be used as signals to aircraft. They are too well known to require further mention.

5. Projectors.[5]

Visual telegraphy can be procured by day or night by means of projectors. Their great drawback is that the smoke during battle materially reduces the visibility.

Besides, while they can easily be used to signal from rear to front, the opposite is not the case, as the enemy could read them as well.[6]

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[1] Mistakes have occurred in discerning these colors accurately through smoke.

[2] 1, 3, or 6 balls. Based on the principles of Chinese fireworks.

[3] The small size facilitates careful packing.

[4] The signals are distinguishable at a distance of about 1 kilo (about ½ mile).

[5] See instructions on liaison of all arms, 1916, pp. 53–55.

[6] Which would draw fire on the signalers.

Nevertheless this method has been proven very useful and was one of the very few which gave satisfactory results during the siege of the Fort de Vaux.

It is also useful for liaison between balloons and earth at night (Verdun, Oct. 24 and Dec. 15), and between earth and all aircraft.

Placed on board an aeroplane. The projector accurately reproduces sound or wireless telegraphy by day or night.

Signal lanterns.[1]

The first apparatus used[2] is a signal lantern, which consists of a sheet-metal box containing:

A projector, made up of a silver-backed mirror and an electric bulb. A sighting piece, made of a tube, the axis of which is parallel to the axis of the parabolic mirror.

A shutter lever.

A battery giving 4 volts.

It can be seen a distance of 500 to 1,000 meters (546.81 to 1,093.63 yards) by day and 1 to 3 kilometers (0.62 to 1.86 miles) by night.

Portable projectors of 14 and 24 centimeters (5.5 and 9.4 inches). These are identical with those described above, except that they have four batteries instead of one.

The range almost trebles that of a signal lantern.

The essential condition for good transmission is to sight the correspondent exactly.

Dynamo projectors.—A 24-centimeter (9.4-inch) projector operated from the wireless dynamo was used with success on an aeroplane.[3] In order to increase the intensity of the light (which was already 100 candles) the inventor increased the voltage of a low voltage metallic filament lamp.

Overheating was prevented by a rheostat operated by the controlling screw of the dynamo. A series of portable projectors operated by magnetos or dynamos and worked by hand have been proposed which would eliminate batteries which are apt to give out or become exhausted.

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[1] See instruction on liaison for troops, p. 54.

[2] The instruction informs us that it is being superseded by the 14-centimeter (5.5-inch) projector.

[3] This test was made with the IV Army. Its luminous intensity is proportional to the square of the increase in voltage.

The 0.10 projector, Continsouza system, is carried on the chest and can be operated by one man. Its range is 1 to 2 kilometers (0.62 to 1.24 miles) by day and 2 to 4 (1.24 to 2.48 miles) by night. The Gaumont 15-centimeter (5.9-inch) apparatus is well made. The dynamo is continuous current, worked by hand with an operating lever making 70 to 80 revolutions per minute and with a current of 40 to 50 watts.

It contains a 16-centimeter (6.29-inch) Mangin mirror and a metal filament light of 13 volts (3.5 amperes) intensity.

The apparatus is completed by a sighting piece. Its range is 2 to 3 kilometers (1.2 to 1.86 miles) by day and 3 to 5 (1.86 to 3.10 miles) by night.

The Poisson machines (25 and 35 centimeters (9.84 and 13.78 inches)) are on the same principles, but more powerful. They were proposed by the technical direction of the military telegraph, but their magnetos were more troublesome to start than the other. One interesting make was mounted on a bicycle,[1] the magneto operated by the movement of the pedals.[2]

Maj. Cornu has made some interesting experiments in lamps with cold light. He has been working on a mercury vapor lamp of intense light requiring very little energy, and has developed a 2,000-candlepower light requiring about 60 watts. Unluckily it is complicated to light, but he expects to make it practicable in a short time. This would solve one of the most interesting problems of liaison: Visual signaling from aircraft to earth by direct light.[3]

CHAPTER III. AUDIBLE.

Liaison by audible signals (trumpets, bugles, horns) has been customary in all wars. This means has only been used during this last war for the past few months, but is destined to render great service, we believe, not only for terrestrial liaison but also between aircraft and earth.

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[1] Studied by the invention section of the Belgian Army.

[2] At fixed posts the spread of the light beams for visual signals should be limited by a series of pierced screens. The interception of messages from the rear to the front can thus sometimes be avoided. The lights are more visible against a dark background. Do not face the sun, and if necessary shade the projector with a screen.

[3] This method (direct light) from aircraft would be far superior to any other existing methods, which are not always entirely satisfactory because of the difficulty in orienting the projector accurately.

1. The bugle.

The ordinary bugle should be replaced by a periscopic bugle which will carry 1 kilometer (0.621 mile). The signals heard with the naked ear, or 3 kilometers (1.86 miles), if the large apparatus described below is used. Practically the sounds will carry 200 to 250 meters (218.72 to 273.40 yards).

2. Special trumpets.

Especially loud instruments are used to carry great distances and be heard over the noise of battle. Capt. Perrin's instrument will carry according to the atmospheric conditions, and no matter what the noise it will carry at least 500 meters (546.81 yards).[1]

Mechanical trumpets are made with circular vibrating reeds, which are operated by carbonic gas under 2.5 kilograms pressure.[2]

One bottle of carbonic gas weighs 2.800 kilograms and contains 1 kilogram of carbonic acid, enough for 200 signals lasting 1 second. The whole is completed by a gas regulator, control levers, and connecting tubes. The message is received with the naked ear or powerful earphones. These phones consist of ear trumpets with an opening of 20° and 1.50 or 1.75 meters long (1.63 or 1.81).

A "honeycomb" voice transmitting and receiving apparatus may be used as receiver also (multicellular ear trumpets, easily used and very sensitive).[3]

Special trumpets were successfully used on the Somme (Chilly) and at Verdun (Bois des Courières) to insure terrestrial liaison of the advanced echelons with the rear. Trumpets seem especially useful on Infantry aeroplanes. The two notes, high and low, can be used for the Morse code. Signals can be made more easily and carried farther from aeroplanes than on the ground[4] (1,000 meters for direct hearing (1,093.63 yards)). This distance is increased by the use of ear phones or amplifiers ("honeycombs") for receiving the signals.

To reduce the weight, 7 kilos, air compressors with reservoirs were substituted for the bottles of carbonic acid. These com-

[1] At the tests we attended it could be heard 4 to 5 kilometers (2.48 to 3.10 miles). The range varying considerably with the azimuth in which one operated.

[2] The trumpets give respectively the notes, solz and siz.

[3] Description of the "honeycomb" will be found in par. 4.

[4] It is interesting to note a similar phenomenon in advance wireless posts. Sound and wireless waves are more easily carried when no obstacles occur.

pressors are governed by a small screw. Any number of signals can be made.[1]

This system seems to us very promising, as fewer mistakes are possible than with visual signals, because the attention is naturally more quickly attracted through the ear than the eye. Visual signals are also apt to be dimmed by smoke or uneven terrain. In aerial liaison during battle the infantryman can not keep his eyes constantly on the plane, and may also be troubled by the smoke.

3. The direction of military telegraph has had powerful claxons made for liaison on the ground.

These devices are operated by pulling a cord wound round a drum. The drum after unwinding is wound up again by a spring.

The minimum carrying range is 200 to 250 meters (218.72 to 273.40 yards), like the ordinary bugle.

Col. Ferrié has authorized the study of still more powerful claxons based on the same principles.

4. Megaphones.

This method of liaison has always been used in the Navy, and it is a known fact that megaphones the walls of which are at an angle of 20° on the axis of the cone have the effect of directing and increasing the volume of the voice.

It is doubtful whether they can be used on land because of the tremendous size necessary to secure the desired range. Capt. Perrin has solved the problem by suggesting a projector of sound waves. Imagine a section cut through an ordinary megaphone the length of L. The same range can be obtained from the portion 1 as with the full voice if it is made up of a sufficiently large number of small megaphones connected to a single mouthpiece (Fig. 1); an apparatus 70 centimeters (27.56 inches) in diameter carried a distance of 700 meters (765.54 yards) in the tests[2]; nevertheless, the voice could not possibly carry so far during battle.

The sound is caught in the sound receiver by the naked ear or through the "honeycomb" at the receiving post, which acts as amplifier.

---

[1] Fifty of these machines are being manufactured, but they do not seem to suffice.

[2] Tests made Feb. 16, 1917, in which we were able to communicate in both directions 900 meters (984.26 yards) (wind velocity, 10 meters (10.93 yards) per second).

Considering the small size of this device, attempts should be made to speak from a plane 200 to 300 meters (218.72 to 328.08 yards) above ground with the earth. Mounted on an infantry or command plane, its service in connecting the rear to the front would be invaluable.[1]

CHAPTER IV. ELECTRICITY.

1. Wire telephone and telegraph.[2]

The telephone systems are considered the nervous system of the battlefield. It is one of the most frequently used means of liaison during military operations. It has two great drawbacks. The lines may be cut, and it also forms an easy intelligence agency for the enemy, "picking up" from a distance being a common method nowadays.[3]

The telephone posts are connected on an all-metallic circuit.[4] The improvement in the telephones during the campaign has been chiefly due to development of the apparatus and care in laying the wires.

Overhead lines are only used in rear of the first positions, as they are too much exposed. The majority of the lines in a sector are protected by following the trenches and conduits, which facilitate their repair in case of need. The most important lines should be buried deep (1.50 to 2 meters (1.63 to 2.18 yards)) to insure safety. According to the type of line to be constructed, bronze wire 15/10, light cable, field cable, armored cable, or lead-wrapped cable may be used.

In order to prevent tapping, all lines must be of double wire within at least 2,000 meters (2,187.26 yards) of the first position and completely insulated.[5] Despite warning, these recommendations are not always observed. It is sometimes considered enough to double the line to prevent conversations being picked up. This is a mistake, because, unless carefully insulated—that is, if the wire itself is in contact with the ground, either because

[1] The German Army now uses sound signals from their aeroplanes. The calls are made by machine guns and trumpets (dots and dashes).

[2] Method usually used on the ground, but also between balloons and the ground.

[3] See note on low frequency amplifiers of the military telegraph, 1916. Note on wireless telegraphy and other electrical means of wireless communication.

[4] Returning by earth conduction is strictly forbidden, as it facilitates the picking up by enemy listening machines.

[5] The German Army use twisted wire.

the insulation is worn or defective—the lost current which results may operate on the German listening phones.

Therefore the greatest caution should be observed in laying the lines in the first positions, the wires mounted on wooden uprights and glass or porcelain insulators.

In spite of everything the telephone is a dangerous device. One is too apt to forget oneself and say things which should be suppressed, and if overheard by the enemy would be immediately turned to account.[1] The instruction on the liaison of troops of all arms (1916) reads (p. 27):

"Never make any allusion over the telephone to events the knowledge of which might in any way benefit the enemy (reliefs, number of units, plans, losses, etc.), unless a telephone code is used."

The German Army tends more and more to supplant the telephone in the first position by the telegraph. Several divisions send all their messages by code telegrams or conventional signals.

Without going quite so far, we believe that a key might be attached to the present instruments which would permit using Morse signals between posts. This transformation could easily be made by the Army telegraphic service.

To insure the continuity of liaison by this method the lines will have to be protected from projectiles and so placed as to be easily and quickly repaired if cut. The lines protected in trenches or boyaux are more easily repaired if they are well placed and accessible.[2] Buried lines should be especially carefully laid, as breaks are usually more difficult to discover.

A shell falling a few yards from the line will cause unequal depressions of the terrain and break the wires.

This will be avoided if the floor of the trench through which the cable runs is carpeted with a wire trellis, or better still the cable run through a wooden case so that the depressions caused by the explosion would be distributed over a somewhat greater length.[3]

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[1] This also applies to conversations with the interior.

[2] It is clear that during a defensive or where the terrain is absolutely chaotic this method will default.

[3] This also preserves the cable from injury by picks, if works are begun later on in the same sector, or from animals, such as rats or field mice, etc. We used it with success at Omes (February, 1916) and Chevalier Wood (1915–16).

In spite of being an eminently satisfactory means of liaison, telephone by wire is almost useless in open warfare. A few days of advancing and the wire and cables would give out, at best sufficing only to connect the principal command posts with each other.[1]

It will take months to lay out the systems already planned. The direction of military telegraphy has perfected a small field apparatus which deserves notice; it is 13 by 9 by 12 centimeters (5.12 by 3.54 by 4.73 inches) in size and shaped like a box, which can be opened or shut and easily transported. It is complete, including the battery. This model should be distributed to every colonel or battalion commander who would find it most useful both during open warfare or a period of passivity.

It is important to realize that the problem of transmitting writing to a distance through telephone lines has been technically solved.

Its most interesting application was made between the headquarters of the Second Army and that of the Central Armies group (110 kilometers (68.35 miles)), when confidential messages were sent safely and quickly by this means. It is impossible for intermediate posts to pick up such messages, and their secrecy is absolute. In addition to this the considerable time consumed in codifying, sending, collating, and decoding messages is saved.

Experience has shown the need for perfecting the quality of certain telegraph lines and regulating the variability of the current of energy. In a short time the necessary improvements will have been made.

These instruments will come into use more and more.

2. Wireless telegraphy.[2]

Wireless telegraphy is the ideal means of liaison during battle. It obviates all question of distance or obstacles. It forms a perfect liaison between the aviator, who can see, and the direct-

[1] It is then necessary to develop other methods: Wireless telegraph and telephone, sound telegraphy, etc., and to have them ready in large numbers. During a period of passivity the total length of wire used in an Army post is enormous. The total length for the system of the Second Army is about 50,000 to 60,000 kilometers (one and a half times the circumference of the earth).

[2] Wireless telegraphy has revolutionized modern warfare to the same degree as the internal-combustion engine, which gave birth to the automobile and aeroplane.

ing commander, and vice versa. It makes the transmission of information from an invested portion to the rear possible, and in the near future will connect maneuvering aeroplanes under one direction.

Wireless telegraphy has, of course, some serious disadvantages, but before discussing them let us see how it is used.[1]

Principles of wireless telegraphy.[2] The two posts communicating with each other each have an aerial. (See Fig. 2.) The sending station makes its aerial vibrate by producing sparks at its base[3] or by communicating electromagnetic impulses by any other means.

These quick vibrations of the current in the aerial are given off in every direction at a speed of 300,000 kilometers (186,414 miles) per second until they reach the receiving station.

The receiving station in turn starts to vibrate in response to the currents induced. Through special instruments these currents act on a telephone which gives off a sound as long as sparks are produced at the sending station or as long as there is any electromagnetic disturbance in the aerial. By shortening or lengthening the receiving aerial[4] one can "tune in" with the sending station—that is to say, get into communication with it. The intensity of the sound signal is thereby greatly increased.[5]

Wireless telegraph instruments are divided in two large classes.

Wireless by spark:

Wireless by means of feebly or strongly damped waves (depending on the type of spark gap).

Wireless sustained by continuous waves:

Wireless by approximately undamped or continuous waves (accomplished by means of a special type of arc or a special high frequency alternate).

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[1] A knowledge of how these phenomena are produced will show how this wonderful use of electricity could be applied.

[2] "Note on wireless telegraphy and devices for wireless communication by electricity, 1916." Direction of Military Radio Telegraphy, p. 21.

[3] By means of an induction coil, alternator, or transformer combined with a key.

[4] This can be done literally, but the same practical result is obtained by using a coherer or a condenser with an adjustable wire. It is then possible to tune in with any sending station, no matter what the length of the receiving station is.

[5] The waves received by the aerial thus increase its own vibration.

Before describing either we shall give the reasons for the gradual displacement of the former by the latter. The reason why wireless telegraphy can not be used on a large scale is because of the confusion resulting from several stations sending on the same or nearly the same wave length.

The first thing is to vary the wave lengths of the different stations in order to differentiate between them. Then, when tuned to a certain station, the connection will be closer and it will be possible to pick it out easily without being bothered by the others.[1] It is also necessary to have the wave lengths sufficiently diverse as not to have the aerial vibrate to every other station.

With a spark station, for example, a receiving station tuned to a sending station with a 300-meter (328.08 yards) wave length would hear sending stations with a wave length of 270 and 330 meters (295.28 and 360.88 yards).[2]

It can be seen from the foregoing that the number of such sending stations capable of simultaneous utilization is necessarily restricted. Another means of distinguishing between sending posts is to improve the connection by increasing the resonance. Instruments of the second type, with sustained waves, can obtain a very high resonance which permits simultaneous talking without confusion with other sending stations whose wave lengths differ by only a few meters.[3]

The scale of wave lengths which can be used is decidedly increased by the adoption of exclusively this type of instrument.[4]

A third method for identifying different sending stations consists in each one adopting a pitch corresponding to different notes=the principle of musical sparks.[5]

A fourth system is that of assigning to each station of the same wave length a timepiece or chronograph divided into sec-

[1] Lecture on means of communicating between aircraft and ground, by Capt. Verdurand (December, 1916), Center of Artillery Instruction, p. 4.

[2] Two spark stations working at the same time should have a wave length at least of 15 per cent difference between them.

[3] Ten meters, for example.

[4] It is to be regretted that this is not already the case. The choice between the spark and sustained wave system is on a par with that between a bicycle and tricycle in regard to equilibrium.

[5] There are several ways in which this result can be obtained. On board airplanes it is obtained by means of a spark gap made of a cogwheel with many teeth revolving in front of a static part.

tors, each station agreeing to work on a given sector. This method requires exact regulation of the chronographs and great attention on the part of the operators. The aviation technical section has a chronograph which is self-locking to the key and which locks or unlocks it during use or nonuse.

A fifth method consists in directing the waves by a special arrangement on the aerial so that it is sent more clearly in some directions than in others.

Nevertheless if terrestrial impulses were received on vertical frames the influence of aerial impulses received by ordinary receiving aerials would be slight or nonexistent.

Wireless by spark.

Sending stations.[1]

Several types of instruments are in existence with the following characteristics (see Fig. 3):

A. Direct-current stations. The aerial is attached to one of the spark-gap poles and the other pole grounded. Both poles are connected to the generator with its key, induction coils with vibrators and its battery of accumulators. In place of the induction coil a transformer with alternator and key is sometimes provided.

B. Indirect-current stations. In this case the spark gap is not connected directly to the aerial, but to an oscillating circuit interconnected with it. The vibrations of the aerial are produced by the action of two coils on each other. The results of induction will be increased or reduced as these two coils are placed close together or withdrawn from each other. Close connection will produce complicated spasmodic vibrations in the aerial unfavorable for receiving and confusing to the surrounding stations.[2]

The Oudin mount is similar to the one just described, the oscillating circuit is derived from one part of the coil and is represented in figure 3.

Receiving stations. The important parts of the wireless receiving apparatus are: The detector and telephone. The signals are received through the telephone.[3]

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[1] A detailed description of these stations will be found in the special notes of the technical direction of military telegraph.

[2] In spite of close connection the sending can be improved by special spark gaps made of a series of parallel disks (spark quenchers) permitting rapid extinction of the spark (shock excitation).

[3] The telephone (see fig. 4) is made up of a horseshoe magnet with two coils at the ends. In front of the poles of this magnet is placed

Hertzian waves induce alternating currents of such high frequency that the telephone makes no sound whatever. The detector is a device which prevents the current from passing but in one direction only, with the result that the waves which reach the aerial are transformed into a series of shocks which can be heard in the telephone.[1]

In order to increase the audibility, vacuum amplifiers are used. They can be received in different ways (see fig. 5):

(*a*) Direct receiving. The detector is attached to the aerial. This is rarely done, as the resistance of the detector materially interferes with the waves.

(*b*) Through electrical connections. The detector is mounted on an oscillating circuit derived from the aerial.

(*c*) By induction. The reaction of the aerial on the oscillating circuit on which is the detector is here caused by induction.

Wireless by sustained waves.

Sending stations. The difference between the waves created by a spark station and a sustained wave station is very great.

In the first the receiving aerial acts like a pendulum, which only swings a few times as the result of a shock and soon returns to its original position.[2] In the second the receiving aerial acts like a pendulum swinging evenly as the result of uninterrupted vibrations of equal strength. Sustained waves are due to a phenomenon produced in a special incandescent light (crooks tube) or a vacuum tube.[3]

It acts exactly like a clock whose pendulum, put in motion by a slight push, continues to swing for an indefinite length of time, actuated by a spring or weight.

Figure 6 shows a mount for a sustained wave sending station. By manipulating the key disturbances will be produced in the aerial which modify the strength of the waves sent out. The technical direction of radiotelegraphy has established sustained

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a thin round disk of sheet iron. This disk follows every variation of the current, the frequency of which varies from 50 to 2,000 or about that of musical sounds. It can not detect the electric vibrations used in radio telegraphy, which are between 50,000 and 3,000,000 in frequency. It is noiseless, which explains the necessity for using a detector with the telephone. (Note on Radiotelegraphy, 1916, p. 31.)

[1] Among the detectors used in Galena. A description of the others which exist would be outside the scope of this work.

[2] The return is due to exhaustion.

[3] See note on wireless telegraphy and instruments for radiographic communications, 1916, page 44.

wave stations for aircraft and for Infantry, which are strong, simple, and light, and which should be immediately adopted.[1]

Receiving stations: The receiving apparatus can be the same as that described above for receiving waves from spark stations.

Nevertheless a vacuum tube is usually used as a detector, connected as shown in figure 6.

In order to increase the resonance or intensity amplifiers can be used again.[2] We shall end this paragraph with a few words on aerials and groundings. Every radiotelegraphy manual will give a description of the various types of aerials used.

The important question during battle is that of rigging an aerial; it is also the most difficult because of shelling.

Only low aerials, easily repaired, can be used in the first positions exposed to enemy fire. An insulated cable laid along the ground can be satisfactorily used and the aerial coiled up after the messages are sent.[3]

The grounding should be complete. Buried 75 millimeters (2.953 inches), cases connected together, or metal trellises, will be good.

If the soil is very dry or strong, wire gauze will act as a balance to the aerial. On board the aeroplane the metal parts of the engine, tank, etc., will form the balance of the aerial.[4]

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[1] The Fourth Army made some tests with an Infantry outpost under the direction of Lieut. Arduin, which gave excellent results. The total weight of the sending and receiving station is 40 kilograms (88.185 pounds) and distributed in four parts.

[2] Amplifiers are unquestionably needed on board aeroplanes in order to be able to distinguish the signals in spite of the noise of the motor.

[3] Signals sent from aircraft can also be received on aerials laid on the ground.

[4] The number of radiotelegraphic stations for terrestrial liaison are at present limited to two for division, because of—

The question of confusion.

The possibility of embarrassing the aerial radiographic liaison.

The possibility of embarrassing telephone conversations and special listening posts.

The danger of the enemy picking up our messages.

These reasons are not very weighty now that sustained waves stations have added so largely to the scale of wave lengths that a certain number can be reserved for the use of the infantry without embarrassing the aerial radiographic liaison. This means would only be used in case the wireless telephone defaulted, and as the messages are very brief the listening stations could not be seriously troubled by them.

The use of conventional signals is obligatory. A reform should be made and the number of wireless stations for terrestrial liaison between the front and rear increased.

3. Wireless telephone.

The problem of transmitting speech over a great distance by telephone has been solved,[1] although no practical use of it has yet been made during the war.

If in figure 6 the key is replaced by a microphone, the wireless telephone has been achieved.

Instead of breaking the current, the variations of the microphone into which one speaks produce disturbances following the modulations of the voice. It is received with the usual apparatus, aerials, detectors, and tubes on the same mounts as already described. The danger from confusion is greater than in radiotelegraphy, but other mounts have been perfected whose resonance is so sharp that several aeroplanes can talk at the same time without confusion,[2] without making such extensive use of wireless telephony as of wireless telegraphy. It should be provided in some cases and gradually developed.

The advantages of this method of liaison might be great. The remote reconnoitering aeroplane would remain in communication with its base; agencies of the command could give the alarm in case of attack or any other important information, and long-distance fire adjustment would be facilitated.[3]

For these reasons wireless telephony will be forced by circumstances into the realm of practicability.

4. Telegraphy by earth conduction.[4]

This is a means of sending vibrations or currents through the ground, carrying variable distances, according to the nature of the ground, and acting on appropriate receiving instruments. The regulation field stations generally carry 3 to 4 kilometers (1.864 to 2.486 miles), but their range can be increased to 8 and 10 kilometers (4.971 and 6.214 miles) by more powerful sending instruments, which we shall mention later. Earth-conduction telegraphy has its advantages and disadvantages; both sending and receiving aerials are dispensed with, but, unfortunately, geological conditions often prevent its use as a field station,

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[1] Not long ago some one in Paris talked with Ypre and beyond with one of the field instruments proposed by the technical direction of radiotelegraphy.

[2] On several terrestrial stations.

[3] The British Army has started work on these lines.

[4] See note on wireless telegraphy and means of radiographic communication used by the aviation and Infantry. (October, 1916, technical direction of the military radiotelegraphy.)

transmission being frequently effected by phenomena, atmospheric or other.[1]

E. C. telegraphy will undoubtedly become an important means of liaison in battle, as it enables the command to communicate directly with any person, at any given moment, and anywhere on the front, by using very simple receivers. The problem of communicating to the front from the rear is thereby partially solved.

The vibrations in E. C. telegraphy are less frequent, a few hundred per second.

The sending station has an insulated conductor, about 50 meters (54.682 yards) long, both ends grounded or attached to buried ground rods or metallic trellises. (See fig. 7.) The sending instrument, consisting of a vibrating coil or an alternator and key, is attached to the conductor. (See fig. 8.)

By pressing the key, a direct or alternating current is passed from the conductor into the ground. This current is propagated in every direction and more or less broken up according to the ground through which it passes. The receiving station consists of a conductor placed parallel to the sending-station conductor and twice grounded. (See fig. 9.)

A telephone is attached to the conductor usually with a 2 or 3 lamp amplifier to increase the audibility. The currents act on the receiving station by induction as they pass through the earth and produce sufficient differences of potential between the groundings to produce sounds in the telephone. By manipulating the key the Morse code can be sent and audibly received.

The sound will be high or low, according to the frequency of the vibrator or alternator, which permits the establishment of several stations on different pitches by which they can be distinguished.

The regulation sets are small and portable. The electromotive forces put into play are less powerful than those of the field wireless stations.

The grounding must be very thorough. Receiving stations with amplifiers of the third type are easily handled. Conductors of sending and receiving stations should be, as far as possible, parallel to each other and perpendicular to the imaginary axis connecting the two stations. Confusion in receiving generally explains why this means is not always successful.

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[1] Frost, for example.

Stray noises usually result from the presence of storage batteries affecting incompletely insulated conductors or producing inductive effects.[1]

These disturbances almost always disappear during battle, as the cables are cut by preliminary shelling and the storage batteries are finally exhausted by the difficulties in the way of supplying the chemical elements and water necessary. Confusion will occasionally result from other causes, such as atmospheric phenomena, as well.

The nature of the soil exercises a great influence. Damp or conductive soil is not always favorable, neither is very rocky or dry soil. A few preliminary trials will show whether it will do or not.

High-power E. C. stations.[2]

More powerful stations, in which the current is stronger, are able to send Morse signals to a great distance. The signals are strong enough to dominate the stray noises and reach the receiving stations in terrain usually considered unfavorable to the regulation apparatus.

The alternator of the automounted field wireless station could be used as a sending instrument with conductors and groundings identical with the regulation earth condition instruments. The high-power alternator,[3] which is that of alternators of the groups of No. 2 cells.

These groups are peculiarly adapted to this use, as they are so constructed as to permit numerous and direct groundings and can send waves 8 to 10 kilometers (4.971 to 6.214 miles), besides which the energy produced makes it possible for anyone to receive the signals anywhere, even in the first line.[4]

To achieve this result it is only necessary to stick two bayonets into the ground, if possible where the earth is a little moist, and connect the two by a field telephone wire to which a telephone is attached.[5]

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[1] Charged wire entanglements or light and power systems.

[2] Very little is known on this subject, but during future battles we feel sure it will be successfully used.

[3] Five and 6 kilometers (3.107 and 3.728 miles) should be anticipated.

[4] This is especially interesting with reference to communicating with the front from the rear. All messages should, of course, be in cipher, as they can as easily be heard by the enemy.

[5] Units which use this means of liaison should have telephone headpieces issued them.

The distance between bayonets should be about 50 meters (54.682 yards). (See fig. 10.) It can be agreed upon in advance that the command would send his signals (or speak) at H+1, H+2, etc., during 2 or 3 minutes, for example. In other words, the command can communicate directly with the entire sector of attack during the battle at a given moment.

When the Fort de Vaux was invested it would have been possible to communicate by these means without interruption from the artillery group to the fort, and a storage battery within the fort would have made it possible to reciprocate as well.

5. Telegraphy by infra-red rays.

The interesting researches made by Commandant Cornu with infra-red rays should be mentioned here.[1] The red rays are emitted by a burner placed in the focus of a parabolic mirror lined with red, in front of which is a disk perforated around the rim. A radiometer[2] in the focus of a parabolic mirror identical with the one just described is placed in the receiving station. A screen held in front of the sending station, and withdrawn at intervals, will produce more or less violent variations in the velocity of the radiometer. The signals may also be received audibly if the end of a speaking tube (diaphragm) is placed in the focus of the receiving mirror.[3]

II. LIAISON TACTICS.

CHAPTER V. LIAISON TACTICS.

1. Object.

During action, whether offensive or defensive, the command should always be in control, therefore[4] he must know the enemy's situation and his probable means of attack and resistance.

He must know the situation of his own troops.

He must issue all the necessary orders to the troops engaged or in reserve.

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[1] These phenomena are between the visual and electric manifestations.

[2] Small mill (?) in a vacuum revolving under the influence of the light. As the rays become nearer infra-red the mill revolves more rapidly.

[3] These attempts are still in an experimental stage.

[4] See "Note to the armies and artillery instruction centers" of the general commanding of the G.A.C. (Grand Army of the Center), Nov. 15, 1916.

The action of the commander should be based on a rapid, easy, and safe transmission of information from the front to the rear and of orders from the rear to the front. Everyone knows how insufficient our means were during the first period of the war. The results were shown in the rigid attacks, in which everything was regulated like clockwork and almost no allowances given for maneuvers. The Champagne Battle (September, 1915) was a typical instance of this kind of operation. Since then great reforms have been made in the methods of transmitting information and orders. Maneuvering was to some extent possible in the engagements in 1916. But there are still many gaps to fill, as we shall see in the following paragraphs:

2. Basic principles of liaison tactics.

The two great divisions in methods of liaison, as reviewed in the first part of this work, were: Terrestrial and aerial.

There are many accidents which can prevent the use of either: Unfavorable atmospheric conditions; destruction of instruments or wires by shell; superiority of the enemy pursuit aeroplanes; smoke, dust, etc.

Consequently:

It is imperative to develop each one as though the other did not exist.

It is imperative to double every means of liaison, aerial or terrestrial, in each echelon by another system, so that communication is always possible in spite of the failure of one or other system.

It is imperative to have the liaisons operate as well from the front to rear as from rear to front.

3. Does the present organization satisfy these conditions?

No.

As soon as telephone communication is broken off or until it is ready the other means are decidedly precarious.

The regulation assignment is shown on Plate III, if we assume the telephone lines to be cut and couriers out of the question.

(*a*) It is clear that our present means do not solve the problem of deployment in depth or width unless aerial liaison is assured.

In case of bad weather and without aircraft, the Infantry is forced to rely on accidental means of liaison and the extensive use of couriers since there is nothing to take their place. The

action is beyond the scope of the terrestrial observing stations. The locating panels do not work, and rocket signals have become hazardous.

(*b*) The frequent solutions of continuity between the various echelons in transmitting information in both directions is striking.

(*c*) It is evident that transmission is easier to-day from front to rear than from rear to front as the means are more numerous in one direction than the other.

Consequently:

The means of liaison at hand are insufficient, both for offense and defense.

Telephone communication should be regarded only as a means of liaison during passivity and not during action or advance.

Visual liaison is precarious and ineffective during action. Couriers are uncertain, slow, and costly, and in the future should only be used in exceptional cases.

The development without further delay of all technical means which might solve the problem is imperative.[1]

From front to rear operated:

Pigeons.

A few couriers.

Projector (with difficulty).

From rear to front:

One courier.

Projector (with difficulty).

To-day numerous means are at our disposal.

From front to rear.

The Naud message thrower (range 400 meters) (437.452 yards).

Telegraphy by earth conduction, high power, with a group of storage batteries within the fort.

Radiotelegraphy, possibly wireless. Telephony, with small aerials.

Audible signals.

From front to rear.

Naud message thrower (range 400 meters) (437.452 yards).

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[1] The actual means of communication from fortified works to the rear are far from efficient.

The case of the Fort de Vaux (June, 1916) is typical. Although our lines were 200 meters (218.726 yards) behind the fort, liaison in either direction was difficult.

High-power earth conduction telegraphy with storage batteries.

Wireless telegraph and telephone with small aerials.

Audible signals.

We feel sure that forts and other fortified works will soon be equipped with the above means.

4. Organization to be attained.

The organization to be attained in the division, which is the combat unit, is shown in Plate IV.

It is not necessarily definite and if applied on a large scale, the proposed arrangement would clearly indicate these capable of future development. The following allotment would be required.

ORGANIZATION OF TERRESTRIAL LIAISON.

1. Wireless telephone. Regulation equipment. The advance troops up to the brigade should have their instruments completed by a key to enable sending code messages by Morse signals.

2. Audible telegraphy.

A. Equipment of special trumpets.

1 for each battalion commander.
1 for the colonel command post.
2 extra, in reserve.[1]
1 for the brigade command post.

B. Megaphones.

1 for each captain.

3. Earth conduction telegraphy (E.C.T.).

1 sending station for each battalion commander.
1 receiving station at the colonel's C.P.
1 highpower E.C.T. sending station for the division.[2]

4. Radiotelegraphy.

1 sustained wave sending and receiving station for each colonel's command post.[3]

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[1] These extra trumpets would either be used on special occasions or for relays.

[2] For example, 1 group of batteries No. 2 of the E.C.M.S. of 6 KVA, 60 periods, 1,500 volts. A receiver can be improvised anywhere, even in the first line, with two bayonets and an ordinary telephone receiver.

[3] For communication with the division, Lieut. Arduin's sending and receiving apparatus would serve. Total weight less than 40 kilometers (aerial, 35 meters) (38.277 yards).

4. Radiotelegraphy—Continued.

2 aerials at the colonel's command post.[1]

2 aerials at the brigade command post.

1 sustained wave sending and receiving station at the division C.P.

2 aerials at the divisional command post.

5. Movable and fixed panels. Regulation allotment (see instruction, p. 56).

6. Projectors. Regulation allotment.

7. Hand message throwers:

2 cases of 12 to each battalion commander for communication with the colonel's C.P. and for advanced echelons.

8. Rockets. Regulation allotment of cartridge signals for the V.B. discharger and 35-millimeter (1.378 inches) pistols for advanced echelons. A certain number of rockets with sticks for the brigade and colonel command posts.

9. Pigeons. Regulation allotment.

ORGANIZATION OF AERIAL LIAISONS.

1. Radiotelegraphy. Until the aircraft can be equipped with sustained wave stations as for terrestrial liaisons, the transition period will have to be accepted.

Every effort should be made to increase the number of aeroplanes working simultaneously on a divisional front.

At present we have two per kilometer (0.621 mile), but where sustained wave stations have been adopted the number can be doubled.

Wave lengths are now distributed as follows:

(*a*) Direct-current stations: 150, 175, 215, 245, 300 meters (164.045, 191,386, 235.130, 267.939, 328.089 yards).

(*b*) Oscillating-circuit stations: 360, 420, 500 millimeters (14.173, 16.535, 19.685 inches).

(*c*) Lamp stations: [2] 550, 700 meters (601.497, 765.521 yards).

Each wave length would use six tones, two for each division. The four remaining are reserved for the adjoining divisions, two for the sector to the right and two for the sector on the left.

[1] One aerial for the Infantry airplane listening station.

[2] Reserved for high-power heavy artillery.

Listening posts for Infantry aircraft:

Special aerials at the colonel's brigade and divisional command posts.

Receiving wireless on aircraft:

1 receiving set on Infantry aeroplane (1 in reserve).

1 receiving set on the Army corps commander's aeroplane (1 in reserve).

Ground stations.—Each aero squadron should have one radiotelegraphic wagon, including a sustained wave sending and a sustained wave receiving station. In open warfare this station would form the liaison with the command posts of the Army corps and Infantry division.

2. Audible telegraphy:

1 special trumpet for Infantry aeroplane (1 in reserve).

1 special trumpet for the aeroplane of the Army corps commander (reserve trumpet).

3. Rockets. Regulation allotment.

4. Aeronautic wire telephone system, regulation allotment.

5. Visual telegraphy. Regulation allotment.

CONCLUSIONS.

As far as technique is concerned, the problem of liaison during battle has been solved.

As far as tactics are concerned, this can not be asserted. Too much use is made of telephones, couriers, and rockets.

These means are insufficient; they may give out at any moment or are not speedy enough for the command to act effectively. Newer methods must be adopted to complete and improve the old.[1]

Wireless telegraphy should be developed on a larger scale, and the construction of portable sustained wave apparatus proceed energetically, as this would be an effective alternative to the telephone service between the division and regiment. It is absolutely necessary to be able to receive wireless on an Infantry aeroplane now-a-days, as it is necessary to be able to speak to it from the ground. Earth conduction telegraphy should be developed and high-power sending stations become regulation, as through them the commander could make himself heard during battle.

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[1] Couriers should only be used in exceptional cases.

Sound telegraphy should become customary, as it is the ideal liaison for advanced echelons. The Perrin megaphone should be immediately constructed. Regulation rockets for V.B. dischargers and 25 and 35 millimeter (0.984 and 1.378 inches) pistols should be manufactured in sufficient quantity to equip the armies.

Message throwers should be generally used in future. Results can not be attained without coordinating all efforts and organizing the liaison service. Each staff, each body of troops, and every echelon should have an officer in charge of the liaison. He should discover the needs, endeavor to satisfy them, and test every new suggestion as well as direct the instruction of those destined to make use of it.

Instructions from general headquarters December 12, 1916 (p. 23), provide for this organization of the liaison service.

PLATE I.

Figure I.

Figure II.

Sending aerial. Receiving aerial.
Adjustable coherer.
Adjustable condenser.
Spark gap. Detector-telephone.

Figure III.

Sending aerial. Oscillating circuit (Tesla).
Generator.

Figure IV.

Vibrating disk.

Figure V.

Aerial. Adjustable condenser.
Adjustable coherer. Detector-telephone.

PLATE II.

Figure VI.

Manipulator=key.

Figure VII.

Amplificateur=amplifier.

PLATE III.

Fusée à baguette=rockets with sticks.
T. O.=Visual telegraph; window-shutter or fixed panels.
T. O.=Visual telegraphy; projectors.
T. S. F.=Radiotelegraphy.
T. P. S.=Earth conduction telegraphy.
Message lestés=weighted messages.
Ecoutes and postes de reception=receiving and listening stations.

The arrows indicate the direction in which it is transmitted; two arrows pointing in opposite directions on the same circuit indicate that the circuit is complete and information can be sent in both directions.

PLATE IV.

Rockets with sticks.
Rockets fired with the V. B. discharger.
Window-shutter panels.
Projectors.
Receiving stations.
T. S. F.=Radiotelegraphy.
T. P. S.=Earth conduction telegraphy.
T. P. S.=High-power E. C. T.
Message throwers.
Listening or receiving stations. (Wireless, E. C. or messages.)
T. A.=Audible telegraphy.
T. A.=Megaphones.

The arrows indicate the direction in which a message can be sent; two arrows in opposite directions indicate that the circuit is complete.

O