Weapons and Munitions of War

Field Equipment for Signal Troops

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The study of the organization and equipment of an adequate service of information in modern war is beset with peculiar difficulties. Cavalry, Field Artillery, and Infantry are rich in literature drawn from the experience of centuries, to which able generals and learned essayists have contributed. It is only in the last quarter century that any marked advance has been made in the art of conveying information in war, which makes it difficult to find extensive or adequate treatment of the subject in standard military writings; in fact almost the entire list of appliances suitable for electric field telegraphy has been devised within the last few years and even noted military writers like Derrecagaix, Gall, James, Baden-Powell, or Lewal have either ignored the subject or have made scant references to it. In some instances they have referred to such service only to remark with regret its short-comings and all too obvious limitations imposed by the complexity, intricacy, or cumbersome character of the appliances required for the transmission of information under war conditions.

To the energy, ability, and devotion of Albert J. Myer, the first chief signal officer of the United States Army, may be ascribed the initiation and development of an organization and equipment that for the first time in the history of the world made possible a sustained and effective system of lines of information for a great army.

Beginning with schemes for visual signaling, which for the first time put that art on a practical military basis of simplicity and universal application, he was instrumental early in the Civil War in introducing the use of the telegraph in the field up to the firing line. Subsequently General Grant appreciated its utility in the broadest sense when, from his headquarters in command of the Army of the Potomac, he directed by wire the strategy which brought the war to conclusion.

Since 1865 the most radical changes have taken place in the armament of troops. The consequent changes in formations, resulting from the progressive adoption of the breech loader, the magazine gun, smokeless powder, and tremendous increase in range and rapidity of fire, have all been toward the wider deployment of troops and the increased importance of concealment and cover. All this has rendered more and more difficult effective command, and for this reason alone there would soon be a limit to further development in this matter, if reliance had to be placed on the old method of communicating orders.

Modern wars have presented examples of fighting lines of great length. Instances are mentioned in Manchuria when more than 25 miles have been spanned. With such development of his fighting lines it is no longer a question what must be done by the commanding general regarding methods of communicating. The most elaborate provision of swift mounted messengers no longer suffices. He must have electric lines connecting him with all his larger units, and of such variety and reliability that practically no mischance may interrupt them. Not only must they be reliable, but they should possess in a high degree the flexibility and mobility which would enable them to follow any rapid movements of the forces to which they are attached. The chief point which is gained by such a system of communications is the concerted action which is such a powerful factor in all successful operations.

Such constant and successful use of field lines were made by us in the Spanish and Philippine wars that the mention of them will serve to remind officers of their constant presence in the field. Our records contain many testimonials of their indispensibility.

We may again cite the frequent and successful use of field lines by the Japanese in Manchuria, where by their means extensive strategical and tactical combinations were rendered possible, which their adversaries were powerless to oppose because they lacked similar effective organization and appliances.

To meet this need, which has so greatly developed in modern war, the telegraph engineers of foreign armies and the Signal Corps of our own army have been organized. The technical requirements to make such service thoroughly efficient are exacting, and the provision of an adequate, properly trained and equipped force for insuring the control by the general of his command, and the concerted action of all its parts, is believed to be worthy of as careful thought as he would bestow upon any part of his organization.

The Signal Corps is by regulations and statutes charged with the duty of collecting, and transmitting information for the army, by telegraph or otherwise, and all other duties pertaining to military signaling.

The following provisional organization of the Signal Corps to serve with a division of troops in the field was approved by the Secretary of War, September 16, 1907.

3 Captains,
9 Lieutenants,
9 Master Signal Electricians,
30 Sergeants, first class,
30 Sergeants,
30 Corporals,
135 Privates, first class,
60 Privates,
6 Cooks.

The following transportation is provisionally approved for the Signal Corps troops attached to a division:

100 Riding horses,
6 Reel carts, 2 horses each,
5 Wire wagons, 4 mules each,
7 Lance trucks, 4 mules each,
6 Instrument wagons, 2 mules each,
3 Instrument wagons, 4 mules each,
6 Construction wagons (escort), 4 mules each,
4 Escort wagons (general transportation), 4 mules each,
9 Pack mules.

No division into separate companies is provided for, since the assignment of such organizations to the duties of laying field lines, visual signaling, wireless telegraphy and balloon operation will be determined by existing conditions.

LINES OF INFORMATION

This general name has been adopted to apply to two or more stations between which military messages are transmitted by means of signals, telegraphy, or telephony.

Under modern conditions lines of information are nearly always operated electrically. On account of its certainty, secrecy, and speed, telegraphy over wire lines is today without a rival for use on military as well as commercial lines.

As an army advances into conquered territory it will utilize as far as possible existing commercial lines to connect it with its base. If lines are constructed, they will generally at first consist of the insulated wires laid on the ground which follow the advance. Such of these as are needed will subsequently be put up as light lines on lances, afterward to be converted into permanent pole lines where necessary. Lines of a temporary character will be constructed or laid connecting the camps. When the army goes into action, an important series of lines are required connecting the commanding general, the corps, division, and brigade commanders, the artillery, and probably important points of observation and control at other places on the line.

Classified as to their construction, lines of information are permanent, semi-permanent, or field lines.

Permanent lines are those similar in construction to the standard telegraph lines, and usually consist of heavy bare copper or galvanized iron wire, Number nine galvanized wire is the standard in our service. These wires are supported on substantial insulators and strong poles. Such lines are generally operated with the standard relays and sounders familiar in commercial offices.

Semi-permanent lines consist of lighter bare wires, usually number fourteen galvanized, supported on lighter poles called lances, or on light tubular iron poles. These lances are fitted with hard rubber or composition insulators. Lines such as these were formerly the standard military construction, and telegraph trains consisting of wire wagons, battery wagons and lance trucks, as described in "Myer's Manual," could construct from seven to fifteen miles of these lines a day, depending on conditions. These lines were generally operated with box relays, but in modern use the telephone would frequently be the instrument employed.

Field lines are those laid hastily for temporary use, and usually consist of insulated wire paid out from reels on carts or wagons, or in the smaller size wire, from hand reels. Sometimes bare wire is used, in which case only the "buzzer" will operate satisfactorily over them. This buzzer is generally used on all field lines, although the field induction telegraph kit may be substituted for it under many conditions. These instruments will be described later.

Classified in regard to their use, lines of information may be considered as either strategical or tactical lines.

Strategical lines are usually of the permanent or semi-permanent character, and may be part of the commercial system of the country. They are "base lines" in general, as they lie behind the advancing army and maintain communication with the base and thence to the seat of government. On account of their importance they would frequently be duplicated, and in general over different routes, to insure communication under all conditions. They would in some cases include important submarine cables, or even large wireless stations.

Tactical lines are generally of the field line class and are rapidly laid or taken up to follow the movements of the units they connect. Their name indicates their uses. They are the "combat lines" which late improvements in wire, transportation, and instruments have made possible.

TRANSPORTATION

In addition to wagons and packs for ordinary transportation, the Signal Corps has found it necessary to devise some special vehicles for transporting and laying wire and carrying such equipment as wireless sets, lances, etc.

The most important of these is the automatic reel cart, holding about ten miles of insulated field wire, from which the wire may be paid out at a gallop and reeled up almost as speedily. The exact type best suited for general use has not yet been determined, although the present form is very serviceable.

For handling the small insulated buzzer wire, which is furnished on half mile spools, the pay-out handle and breast reel answer every purpose, either on foot or mounted.

The instrument wagons are spring wagons provided with paulins or wagon sheets in which instruments, light tools, repair parts, etc., may be transported.

The lance truck is a wagon with a high seat and long reach, suited for the transportation of from 250 to 300 lances eighteen feet long. Four mules suffice for this load under ordinary conditions.

The balloon train requires two special wagons; one for transportation of the steel cylinders, about seven feet long and ten inches diameter, in which the compressed hydrogen gas is carried, and another called a winch wagon with engine and drum for paying out and recovering captive balloons.

Special pack chests are provided for the Signal Corps supplies, and the present field wireless pack set, which is carried on three mules, requires special fittings for the aparejos.

TYPES OF WIRE

For the permanent military lines, number nine galvanized wire weighing 320 pounds to the mile is the standard.

For semi-permanent lines, such as lance lines, number fourteen galvanized wire weighing about 100 pounds per mile is used.

The two kinds of wire used in field lines are known respectively as "field wire" and "buzzer wire". The former corresponds with the "field cable" used abroad. Our field wire consists of a larger copper wire surrounded by ten small tinned steel wires of very high tensile strength. This is covered with a layer of cotton, then vulcanized rubber, and an outer coating of braid which is saturated with an asphaltum compound. The whole is about 1-8 inch in diameter, has a tensile strength of over 300 lbs., and weighs 70 lbs. per mile. Ten miles of it may be carried on the drum of the latest type reel cart. Its strength and insulation are little impaired by wagons and troops passing over it. It is very pliable and lies flat on irregular ground. As it is laid, mounted men follow the reel cart with pikes or lances having hooks on the ends, either placing the wire out of the way on the road, or if need be hooking it up on trees. It is difficult to break or injure this wire unintentionally. If found broken, instructions have recently been issued to the Army showing the proper method of quick repair. This is done by tying the ends together with a hard knot, leaving about a foot of each free. The insulation is then removed from the ends for several inches and the bare wires twisted together.

Buzzers or field telephones may be quickly connected with this wire by means of steel clips attached to pieces of flexible wire. These clips are furnished with sharp teeth that pierce the insulation readily, and when withdrawn damage the wire very little.

In every way this type of wire seems eminently suited for field lines, the only objection being its cost, which is about $75.00 per mile.

A small wire of this class, suitable for laying from a hand reel, is called "buzzer wire". This consists of two fine steel wires and one of copper covered with cotton saturated with compound. This wire weighs about 10 lbs. per mile, and is put up on half-mile spools. This permits paying out the wire from a simple holder from horseback, and its recovery by means of a breast reel. This wire is used for short lines or for emergency lines over rough ground where the heavier field wire cannot be carried.

It may be useful to remember that since buzzers will operate over long stretches of bare wire laid on the ground even in wet weather, field lines of any kind of wire available may be laid in emergencies.

INSTRUMENTS FOR ELECTRICAL LINES OF INFORMATION

Base lines and other permanent telegraph lines will of course make use of the familiar commercial apparatus. Morse instruments of various portable forms, such as the box relay, main line sounder, or pocket relay, will be used on semi-permanent lines wherever practicable. These require, however, large battery equipment and well insulated lines, and in bad weather the instruments are difficult to keep in adjustment.

THE BUZZER

On our field lines the buzzer in one of its forms is almost universally used. This instrument was introduced into our service about 1890 and first showed its capabilities in the Philippine and China campaigns. In its present forms of "field buzzer", and still more portable "cavalry buzzer", it combines in a small leather case weighing a few pounds a complete telegraph and telephone station including the necessary batteries. Its capacity for working over circuits impossible for any other telegraph instrument, such as bare wire lines laid on the ground, through wire of wire fences, or railroad rails, or more incredible still, through considerable breaks in the line when the ends lie on the ground, makes it the ideal instrument for field lines.

To open a station it is necessary only to fasten the clip with flexible cord from one binding post to the field wire, and from the other binding post a flexible wire leads to a small ground-rod or metal peg driven into the ground. In emergencies the ground wire may be held in the hand, or when used mounted, may be connected to the horse by a small metal plate under the saddle blanket.

By working the key an interrupter is operated giving a high singing note, which is broken up into the dots and dashes of the Morse alphabet. These correspond to vibratory electrical impulses which go out on the line and are heard in the telephone receiver at the distant station. The efficiency of the buzzer under the difficult conditions stated is due to the marvelous sensitiveness of the telephone receiver to these rapidly pulsating currents. In practically the same circuit as the interrupter is a telephone transmitter, and when the button switch on this is depressed the instrument becomes at once converted into a very efficient telephone set.

The cavalry buzzer is the lightest, weighing about 4½ pounds, and comparable to a good sized field glass in dimensions. It has not so much power as the field buzzer which is about fifty per cent heavier and bulkier. For buzzer telegraphy over difficult lines the field buzzer's superior power will probably make it the preferable instrument.

THE FIELD TELEPHONE

This instrument contains in very compact form the essentials of the ordinary telephone set, namely: the magneto generator, call bell, receiver, transmitter, induction coil and two cells of dry battery. It has all the power of the most complete telephone. The box is very strong and weather proof and has a strap for convenience in carrying. The transmitter and receiver are attached to a handle containing a switch, which is depressed by the fingers and brings the battery into operation when talking. The connections are very simple and easily repaired when deranged. It can be connected to field lines and the ground in the same way as the buzzer. Its commonest use, however, is for camp lines where, with its generator and call bell, it is specially suited for connection with the field switchboard. This latter instrument has ten drops and can take care of connections with ten lines, or more telephones if party lines are practicable. This switchboard uses cams for making connections, instead of the cords and plugs of the commercial switchboards, thus saving greatly in bulk and securing greater portability.

FIELD INDUCTION TELEGRAPH

On semi-permanent lines, especially where business over them is heavy, the continual use of the buzzer is very fatiguing to Morse operators. The field induction telegraph set, permitting the use of the ordinary sounder, has been devised especially for this class of lines. The case, furnished with a carrying strap, weighs about twelve pounds. In this are a polarized relay, sounder, key, four cells of dry battery and a special form of induction coil. By means of this induction coil the operation of the key sends out impulses of high voltage over the line and relays. These relays are very sensitive and operate with a remarkably small current. As a result of the voltage increase and relay sensibility, three of the dry cells will work the sets over hundreds of miles of iron wire, over ordinary circuits where the insulation leakage permits the escape of ninty-five per cent of the current. Doing away, as it does with carrying large amounts of battery, it is believed to be a useful intermediate instrument betwen the buzzer and the regular telegraph installation.

SELECTION OF INSTRUMENTS

It thus appears that the buzzer, the telephone, and telegraph each has fairly well defined roles in operating electrical lines of information. The buzzer is the pioneer which clears the way, follows up the fighting line and can operate over any kind of a line. Its function as a telegraph instrument is the paramount one on account of its reliability, although as stated it is a good telephone when the wire is in proper condition. The field telephone is most useful in camp administration lines or over semi-permanent lines in general, where telephone service seems desirable.

The telegraph is standard where lines are established and where the volume and importance of business become great. To the trained operator there is nothing to equal the clearness and certainty with which a message on a Morse sounder is delivered, and such operation is the ultimate excellence toward which military lines aim.

The decision as to when the telephone or telegraph should be installed or used is governed by the following considerations:

The telephone does not require trained operators.

The telephone may be used for direct, and consequently confidential communication between officers.

Time is saved, compared with telegraphy, especially when the users are accustomed to the telephone.

The telegraph is superior to the telephone in the following ways:

Accuracy.—A written message, spelled out by telegraphy, written and delivered, has an obvious advantage over one delivered by word of mouth.

Reliability.—In the field, especially when the wind is blowing in the ears and various other noises tend to confuse, it is very hard to distinguish in the telephone words which sound alike. This is especially confusing to an enlisted man unused to expressions common in military messages. The sharp signals on the buzzer or sounder are much more reliable.

Speed.—It is found in the case of written messages transmitted by buzzer and telephone, that, owing to frequent repetitions required by telephone, the buzzer will generally exceed it in speed.

From the foregoing considerations, it is evident that officers should, when time permits, always write out their messages in proper form. The use of the telephone should be restricted to communication between officers. The direction to an operator verbally to send messages by telegraph is very inadvisable. Sending messages by dictation through the telephone invites almost certain errors.

FIELD WIRELESS TELEGRAPHY

Wireless telegraphy, the newest competitor for favor as a means of conveying information, has gone through the spectacular stage in public estimation, and appears to have settled quite completely into its unique and useful field as the commercial agent for telegraphy when it is either impossible or too costly to run wires or cables. Its peculiar fitness for field lines of information was at once appreciated. The advantage, especially in this regard, of a system which requires no wires over one which does, is at once apparent. Accordingly, the armies of nearly all prominent nations have made progress in developing portable wireless sets. Abroad, Germany has led in this matter and some of the Telefunken Company sets have given excellent results. England has experimented with Lodge-Muirhead sets, Italy and Russia with some devised by the Marconi Company, and France with those of several French inventors.

The Signal Corps, after vainly endeavoring to secure suitable apparatus, was compelled to take up not only the devising but also the assembling of such apparatus. After two years of constant work to improve it, our smallest field set, suitable for pack transportation, it is believed may challenge comparison for efficiency, simplicity, and compactness. The latest pattern consists of two small chests, approximately sixteen inches cube, containing the operating apparatus. The source of electric power is either two small storage batteries or a hand driven dynamo on a stand—or better, both used simultaneously. To support the necessary aerial wire or antenna, a sectional hollow mast sixty feet high of reinforced spruce is provided. Six wires eighty feet long radiate from the top of this. Instead of attempting the perfect ground connection, which would be needed, six wires are used, radiating from the base of the mast and supported about six feet above the ground. This is called the "counterpoise". The mast and raising device require twelve sections, each six feet eight inches long. The counterpoise supports are the same length. These and the necessary guys and accessories weigh about 140 pounds and constitute a load for one mule. The batteries or hand generator weigh about 120 pounds and make a load for another mule. The two chests containing operating apparatus weigh about 130 pounds and go on the third mule. The whole set, weighing 390 pounds, stows readily in the instrument wagon. The range of this set, with another like it, is thirty miles, although twenty miles can be more safely counted on. A station can be established within fifteen minutes.

Another form of field wireless apparatus, called the "one kilowatt set", weighs within 1,000 pounds, and consists of four parts—the operating chest, transformer chest, generating set, and ninety-foot sectional mast. The generator set consists of a one kilowatt alternating dynamo driven by a gasoline engine on the same base. These sets have given good satisfaction in the tests in Cuba and Leavenworth, and may be considered as successful types. Their range is about 100 miles.

At present a chain of high power wireless stations is being put up by the provisional government of Cuba, extending the length of the island. The interest this has for field communications appears when it is stated that one of the small field sets could, at any point in Cuba, be in communication with at least one of these stations. The strategic value of such a line becomes evident, and points the way in which the establishment of large wireless stations would proceed during an invasion. The small field sets can operate with considerable certainty for 100 miles with the large permanent stations.

With all its freedom from interruptions peculiar to wire lines, the wireless has at present many limitations of its own. It lacks the simplicity and compactness of the buzzer. It is susceptible to rather frequent interruptions from adverse atmospheric conditions. Its signals go in every direction and can be picked up and read by friend and foe alike. Adjacent stations will generally interfere, although means exist which will largely prevent this.

The time required to put up and take down stations will frequently make the wireless of little use for tactical lines as compared with field lines operated by the buzzer. Many instances, however, will occur when the possession of such a means of communication will prove of inestimable value in the field, and every effort will be made to develop and perfect it.

VISUAL SIGNALING

Electric lines of information have been so greatly developed in importance by the improvements of the past few years, that visual signaling has been largely overshadowed. Although relatively of less importance, its actual value has probably diminished but little, and there will be many occasions when a knowledge of its capabilities will prove of immense importance in the field.

The principal means for conveying visual signals in our service are the flag, the heliograph, and the acetylene lantern. The two former are for day signals, the latter for night. For briefer code messages the smoke bombs or rockets for daylight use, and for night use the sequence rockets, bombs loaded with red or white stars, and the Very pistol, shooting colored stars like a Roman candle, are occasionally serviceable. In the navy and at coast artillery posts, night signals may be conveyed by mean of the Ardois lights or by searchlight.

Messages are spelled out in signals in accordance with the Army and Navy code, generally called the Myer Code. It is a three element code represented by right, left, and front motions of the flag; single, double, or prolonged flashes from the lantern and heliograph; different colored lights in the Ardois, sequence rockets, or Very pistol stars. Combinations of these make up letters, numerals, or signs for abbreviations. The number and order of the signals with the heliograph, lantern, or flag and the number and positions of the colored lights in the Ardois or sequence rockets, determine the letter, numeral, or abbreviations.

The many ways in which means may be quickly extemporized for sending visual signals, make a knowledge of them useful in proportion to the skill of the signalists—for there are frequent occasions when their use would save travel and valuable time.

Flags.—In our service these are square flags either red with square white centers, or white with square red centers. The white flags are for use against dark backgrounds and the red for use against light ones. Two sizes of flags are used, two feet square and four feet square respectively. These are put up in kits consisting of two flags, a red and a white, of the same size, with a set of three-joint bamboo or wood staffs put up in a canvas carrying case. All three joints are used to signal over the longer distances.

Signaling with flags is limited to very moderate distances, usually not more than five miles, unless conditions are exceptional, permitting the use of very high power field glasses or telescopes.

The Heliograph.—This is an instrument for signaling by means of sunlight flashed from a plane mirror or mirrors. The mirrors are carefully selected to prevent dispersion and diffusion of the sun's rays. These flashes are sent singly or in pairs, representing the "1" or "2" of the Myer code, respectively. The mirror or mirrors are adjusted to send the flash steadily to the distant station, and a tripod carrying a sectional shutter is interposed in the path of the rays. This shutter is controlled by means of a key like that of the telegraph in shape and operation, which rotates the leaves of the shutter and shuts off or permits the beams to pass. The brightness of this beam permits signaling to great distances—in one case, where conditions were favorable, signals were sent about 180 miles. The readiness with which the shutter may be worked permits greater rapidity in sending than with the flag. As clear weather at both stations is required, this limits the reliability of the heliograph. When operation is possible, however, its speed, great range, and invisibility in all directions except in the line of the beam, make it superior to other means of visual signaling.

The Acetylene Lantern.—This is, briefly, a small searchlight mounted on a heliograph tripod in which acetylene gas is the illuminant. It is provided with a key, like a telegraph key, for turning the gas off and on intermittently, which gives the intermittent flash signals. Hanging under the lamp is a small generator for producing acetylene gas from calcium carbide. This carbide is contained in a small tin cartridge which is opened at the ends just before placing it in the generator. The small tank is partly filled with water which rises in the carbide cartridge and generates the acetylene. Normally, this burns in a very small flame at the burner, but when the key is depressed, the gas is turned on fully and a brilliant light results. At the rear of the lantern case there is a parabolic mirror about five inches in diameter. The flame is at the focus of this mirror, so the emerging rays are parallel. The front of the lantern is closed with plain strips of glass. The whole lantern, generator, repair parts, and four spare cartridges are packed in a ten inch cubical box. This lantern is a most dependable instrument for night signaling and has a record of thirty miles for such work. The light from acetylene gas has great power of penetrating fog and haze, being rich in rays from the red end of the spectrum.

Rockets, Bombs, and Very Pistols.—These are of rather exceptional application, yet on occasions they may prove of great importance. The rockets are of the sequence or smoke varieties, in which a paper parachute is released at the top of the flight carrying stars of colored fire composition in the sequence rocket, and a smoke producing composition cartridge in the smoke or day rocket. The colored fire burns in red or white, corresponding to "1" or "2" of the Myer code. Reading these in succession these lights may thus correspond to a letter or numeral and give a code message in the same way that the Ardois lights do. These rockets are furnished with sectional sticks that screw together. These sticks, the rocket, a box of matches and a small port fire are put up in a tin can, and the top is secured by a readily removable soldered tin strip, making the whole waterproof and practically proof against ordinary accidental ignition. Rockets mount to as much as 1,500 feet.

Bombs are of three kinds—red star, white star, and smoke bombs. Bombs are fired from steel mortars made for the Signal Corps by the Ordnance Department. Great care should be taken to put the bomb in right side up, to bank earth or sand bags around the mortar and to light the fuse with a long stick. The smoke bomb projects a parachute carrying a slow-burning mass of smoke-producing composition which gives a daylight signal. These bombs are put up in tin in the same way as the rockets. Bombs mount to a height of about 500 feet.

The Very signals are single colored stars fired from a pistol. White, red, and green star cartridges are furnished. These signals are of course available only over comparatively short distances, but their certainty of action and portability make them occasionally useful.

CODES

Code books are tables of code words which stand for phrases, or sentences, and permit of abbreviating messages very greatly. There is a distinguishing number for each code word, which permits of enciphering as will be explained. The War Department code book compiled in the Signal Office, and the Western Union code, are those most frequently used by officers. In the front pages of each are directions for using these books. Practice in coding and deciphering messages is commended to officers, since facility in this regard may save much time at critical junctures in the field. Brief codes in which much information may be conveyed by a few signals or even a single one, are frequently of use for special occasions. Rocket and bomb signals are examples of these.

CIPHERS

A cipher is a secret mode of writing. A good cipher should be easily made up; is easily deciphered with the key, and bears no evidence on the face of being a cipher. Few comply with all the requirements. Familiarity with the enciphering and deciphering of messages is a valuable accomplishment, since any message of importance should always be enciphered. The code book may be used not only for abbreviation but for enciphering also. For example, instead of writing the word representing the desired phrase we add to or subtract from its code number a preconcerted number or numbers, and use the word opposite the resulting number. The correspondent by reversing the process on the number opposite the word sent, will find the number corresponding to the word desired. These additive or subtractive numbers may correspond to the numerical positions in the alphabet of the letters of a key word previously agreed upon, and still further complicate the cipher.

For enciphering ordinary messages, the Signal Corps furnishes the cipher disk. This consists of two concentric disks of cardboard or celluloid, the upper, and smaller, revolving on the lower. On the circumferences of each are printed the alphabet and numerals or other signs, clockwise on the outer, and anti-clockwise on the inner. To encipher with this, by using a key letter previously agreed upon, the key letter of one of the disks is placed opposite the letter A on the other. The letters or numerals of the message are selected in succession on one of the disks, but the corresponding letter on the other disk is the one written in the message to be sent. This apparently meaningless collection of letters may then be deciphered by the recipient by means of a disk set with the proper key letter. This simple cipher is comparatively easily deciphered, even without the key letter. To render it more difficult to decipher, a key word or sentence may be agreed upon and the cipher disk changed to a corresponding new key letter each time a letter is enciphered.

In place of a disk, means may be extemporized by taking two strips of paper, on one of which the alphabet, numerals, etc, are twice written in succession. On the other, with equal spacing, the alphabet, etc. are written once, but in reverse order. By sliding these strips in juxtaposition with each other, they will replace the disk.

In the sixty pages of the old Signal Corps Manual by Myer, dealing with this supject, many ingenious and interesting methods of enciphering by cryptograms, and otherwise, are described.

FIELD GLASSES ~~AND TELESCOPES~~

Field glasses are issued to companies, troops, and field artillery by the Signal Corps. The most serviceable makes for the various branches have been settled upon, only after prolonged practical tests. These are, for cavalry and infantry, glasses of the Galilean pattern of low powers; and for field artillery, the same pattern with higher powers and interpupilary adjustment. Each glass is of two powers, the infantry and cavalry glass of 3 1-2 and 5 1-2, and the field artillery one of 4 1-2 and 6 1-2 respectively. This double power is secured by having small eyepiece lenses which fall into place when the glass is turned with the high power side up, and which fall aside with the low power up. The lower power is useful when on horseback, when the light is bad, or if the weather is hazy.

Another glass that is issued for the observers' use in field artillery is the Terlux prismatic glass having a power of 10. This can be used under favorable conditions, and is a glass of remarkable qualities.

Field glasses are called upon to fulfill a number of conditions which make it impossible to select any one which meet all of them. The qualities of high power, sharp definition, abundant light, and large field of view, are all desirable. When these are added to those highly requisite military ones of compactness and serviceability, it is found impossible to obtain all in one glass. For use on horseback or when the light is dim, low powers are requisite to obtain steadiness and sufficient illumination. Increased field of view can be obtained in any pattern of glass only by lowering the power. The general tendency in purchasing glasses is to call for high powers, but for average use powers greater than six or eight will frequently cause disappointment.

The Terlux glass though of the more complicated and expensive pattern, has larger object glasses and consequently gives greater light than other prismatic glasses, but its much greater bulk and weight are against it as well as the unsteadiness due to the greater power. Having the prisms on each side combined in one piece of glass makes it less liable to derangements in adjustment than other prismatic glasses.

MILITARY AERONAUTICS

In every war of importance since the Montgolfiers made the first hot air balloon in 1783, balloons have taken a part. Captive balloons have long given valuable service for reconnaissance, and free balloons have been used for the transportation of persons and messages from besieged places. In recent years, with well equipped balloon trains and the hydrogen gas carried compressed in steel tubes, it is possible for a well trained detachment to inflate and put a captive balloon 2000 feet in the air in 30 minutes. It has been shown in a number of tests abroad that captive balloons are most difficult objects to hit, and at distances of three miles and heights of above 1500 feet they cannot be successfully attacked by artillery.

Punctures of the gas bag with bullets have very little effect, although, if reports of experiments made in France recently are reliable, a new bullet with slow burning fuse composition in the base, has been successful in firing small test balloons filled with hydrogen. Captive balloons make portable observing stations from which, at heights of several thousand feet, observations may be taken, reports telephoned directly, sketches and photographs made, thus amply justifying the expense and trouble of maintaining balloon trains.

The fact that they have occasionally been used with poor judgment should not be permitted for a moment to weigh against the decided advantages which their proper use gives to the army possessing such an equipment.

The captive balloon is usually spherical in shape, and is furnished with a wickerwork car suspended from the netting over the balloon by means of ropes. It can not be used in winds of over twenty miles per hour. A form of captive balloon originated in Germany, called the "Dragon" or kite balloon, is of an elongated shape with wings and air bags attached, so it rides like a kite and can be used in wind up to forty miles an hour. The range of observations from balloons may be up to ten miles, although in general the observations are of little value beyond five miles when it is necessary that details be distinguished.

In addition to their limited field as a means of transportation from beleaguered places, free balloons may, under favorable weather conditions, be used in the same way as captive balloons. Data may be sent to and received from them by means of wireless telegraphy as has been shown in recent tests in Germany, and in the United States by the Signal Corps.

NAVIGATION OF THE AIR

Navigation of the air has appealed so powerfully to popular fancy and so much has been published concerning it, that it is difficult to sift real achievment from optimistic predictions, or adventitious feats from advances which may be regarded as safe and conservative,

We have arrived at that stage of perfection in aeronautical devices, when it may be said with confidence that the dream of the ages has been realized, and man may fly. With many successful military dirigible balloons, and long flights of heavier than air machines, we must take into account in all future wars the presence of such aerial scouts and the means of utilizing our own and combatting those of the enemy. All that has been said of the utility of captive and free balloons is true of the dirigible, and its military value is obviously so much greater than either of them that there is no question as to which would be generally used, where captive, free, and dirigible balloons are all available.

Before proceeding with descriptions it will be well to examine the terminology which the rapid elaboration of devices for aerial navigation has rendered advisable. Two general classes of flying machines exist.

First, those utilizing a gas bag for flotation.

Second, those depending upon the dynamic reaction of the air against their moving parts for sustentation.

Further classification, approved by the Permanent Aeronautic Commission, is as follows:

An *aeronat* is a dirigible balloon. All other balloons would be called *aerostats*. The pilot of either would be called an *aeronaut*. Heavier than air machines (having no gas bags) are called *aeronefs* and these are subdivided into kinds depending on the mode of sustentation as follows:

Orthopters are those in which sustentation is produced by the motion of planes like the beating of wings.

Heliocopters are those in which the effect is produced by the revolution of propellers in a vertical position. A number of flying toys are of this variety.

Aeroplanes are machines driven forward by the propellers, and the reaction of the air against the inclined planes causes the machine to rise when a sufficient velocity has been attained. Aeroplanes may be *Monoplanes*, *Biplanes*, or *Polyplanes* depending upon the number of planes superimposed. The aeroplanes are the only kind of aeronefs that have made practical flights, although several promising results have been obtained with the heliocopter. Among aeroplanes those of the Wright Brothers, Farman, and Delagrange are all of the biplane pattern, and these are the ones which have made the record flights. The pilot of an aeronef is called an *aviator*. The balloon house or aeroplane shed has received the name *hangar*.

Since dirigibles and aeronefs all require compact and powerful motors, the possibility of obtaining suitable ones has depended entirely on the development of the automobile gasoline engines. Skill in the management of automobiles, then, is an excellent preliminary qualification of an aeronaut or aviator. Furthermore, the former would find a full knowledge of aerostats very useful before attempting the management of the dirigible.

DIRIGIBLE BALLOONS

The success of these for several years past has induced all prominent nations to secure some of them for military purposes, France has, as usual, led in aeronautics, and has at least four large dirigibles completed, and orders placed for additional ones for the use of its army and navy. Germany has three, and others building. England, Spain, and Italy each has one, and it is reported that Russia and Switzerland are soon to be supplied. The United States has a small experimental one, but it is hardly powerful enough to be counted among those possessed by the countries named.

Dirigible balloons are of the rigid, semi-rigid, and non-rigid types. The first has a supporting framework of aluminum parts. The Zeppelin balloons are examples. The semi-rigid has a framework along the lower part which supports the car, and incidentally helps to keep the gas bag from collapsing longitudinally. The non-rigid depends entirely on the ballonet to keep the bag from collapsing. This ballonet is an interior compartment which can be inflated with air or deflated at will, and thus provides for changes in pressure of the hydrogen. The late French balloons are types of the semi-rigid, and the Gross and Parseval German dirigibles of the non-rigid. Our own experimental dirigible might be classed with the semi-rigid. The rigid type is necessarily of large size to compensate for the weight of the framework. The Zeppelin was 413 feet long and 38 feet in diameter. It had a record of thirty-eight miles per hour, and travelled at one time more than twelve hours. For field use, when either no hangars or only those of canvas are available, it is evident that the semi-rigid or the non-rigid types are suitable, since quick deflation will frequently be required to save them. It appears that for fortress and seacoast defense where suitable hangars can be provided at stated intervals, the large, high-speed, weight-carrying, rigid dirigibles like the Zeppelin may be the best, while for strict field reconnaissance work the non-rigid types, as stated, will prevail. Colonel Capper, R. E., the English military aeronautical expert, in a lecture last spring has stated so clearly the probable rôles of dirigible balloons in warfare that I cannot do better than to quote him.

"It appears to me that we shall have to possess two different classes of vessels. The first will be the comparatively harmless small class of balloon of from 70,000 to 100,000 cubic feet capacity, to be used for scouting, and possibly for attempts by destroying, by high explosives or incendiary mixtures, important iron bridges or store depots close to the army fortress; or for harrassing the enemy by dropping a few bombs into his camps at night, and so keeping him constantly on the qui vive.

"It is probable that a reconnoitering balloon to be safe during the daytime will have to maneuver at an altitude of at least 5,000 feet, from which height only large bodies and important movements would be readily visible. At night, however, a balloon can descend with safety to within a few hundred feet of the ground, and may get valuable information. Even on a bright moonlight night it is difficult to see a balloon at 500 feet up, and it is very difficult to keep a searchlight on it. With a light wireless apparatus in the balloon much valuable information might, under favorable circumstances, be obtained, without undue risk of losing the vessel. In any case the cost of such a vessel is comparatively small, and the loss of a few would be a small matter to the army.

"The radius of action of such a balloon will be, perhaps, 100 or 150 miles.

"The second class (and the more important one if really seriously developed) may revolutionize the strategy of war.

"Large vessels of from 500,000 to 1,000,000 cubic feet capacity, capable of traveling at a speed of 40 miles per hour in a calm, and of carrying considerable quantities of high explosives, can set out and with a favorable wind, can cover vast distances in a few hours. When they will come, and what their objective will be, cannot possibly be known to the enemy, who cannot always be looking with guns ready pointed into the air; whilst they will pass over country so quickly as to be out of range almost as soon as seen. Keeping high up in the daytime and descending at night, they can keep their direction with practical certainty, and hovering close over any desired spot, may launch explosives with delay action fuses, which will enable them to retire to a safe distance before the explosion occurs; or they may even risk destruction to effect some notable exploit.

"Their objectives would be not the enemy's armies, but his dock-yards, arsenals, storehouses, railway centers, etc., where the maximum of damage can be caused at a minimum of cost. Possibly they might even attack the enemy's navy if he has one; but probably the same effect would be produced in a more humane manner by merely destroying the docks, etc.

"There would appear to be but little difficulty in lodging the explosives with great accuracy if good plans are available to work by, whilst the expense, even should several airships be lost, would be insignificant."

AEROPLANES

Such a sensational progress has been made in flying by means of aeroplanes, that practically the whole recorded success in this line has been attained in the last few months. For several years before this the Wright brothers had been conducting private experiments; and although their recent achievements were marred by the accident in which Lieutenant Selfridge lost his life, they have shown in this country, and in France that flights of more than one hour may be sustained with two passengers in the aeroplane, and speeds attained approximating forty miles per hour.

The most precarious feature of all aeroplanes is the maintenance of stability. This the biplane appears to accomplish most readily. It is not difficult to obtain motors light and powerful enough, and framework and propellers strong enough, to be combined in a machine which will raise itself by the dynamic reaction of the air against the inclined planes. Only the Wright Brothers seem to have succeeded in arranging horizontal and vertical rudder planes, in changing the shape of the main planes to steer with certainty, and in meeting the tendency to careen, which brings most of their rivals to grief. The fatal accident in Washington seems to have been due to a small structural weakness in an obscure part, rather than to any fault in design or management.

The part aeroplanes and other aeronefs will play in military aeronautics can hardly be predicted as yet. Professor Simon Newcomb, in a recent scholarly article goes so far as to state that they must always remain unreliable, dangerous, and of rare application to the needs of mankind. Whatever may be their success, it would appear that they will be applicable only to the transportation of the lightest loads. For any aerial weight-carrying, the dirigible appears to have the advantage. It will probably be the battleship of the aerial fleet, as compared with the aeroplane torpedo craft.

With regard to the discharge of projectiles or torpedoes from airships, there seems to be a misapprehension as to the agreement at the last Peace Conference at the Hague. The United States alone among the great signatory powers agreed not to discharge missiles from airships. This operates practically as if there were no such article, since the article itself provides that the protection does not extend to powers not signing the agreement.

The very recent successes in aerial navigation make it impossible as yet to forcast what effect its introduction may have on the art of war. Vast possibilities loom up, and the matter is already being seriously considered abroad. The bearing that such devices have on strategy has been aptly compared to a game of chess in which the opponents furnish each other beforehand with a list of moves proposed to be made. What war may be, with every foot of our terrain for hundreds of miles under the constant watch of an enemy, must be at present largely a matter of surmise.