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VISUAL SIGNALLING.¹

By EDWARD J. C. RAMBUSCH (Premierlieutenant, Royal Danish Engineers).

Introduction.

ANY object, any movement, in short any thing, that confers upon our minds a conception different from the impression which its appearance calls forth to the senses, may be considered as a visual signal. Indeed, visual signals—the word taken in this sense—are far more frequently applied in every day life than they appear to be to such as do not examine the matter closely. Thus the letters of the alphabet may be considered as a kind of visual signals; they can confer upon one's mind a certain conception, beforehand agreed upon, that must be learned before it is understood. Every child knows the visual signal given by a raised forefinger, a nod with the head, a shaken fist, or many other signs in common use, although those signs in themselves signify nothing, and their meaning is to be learned before it is understood; yet many are these simple visual signals, that are known and made use of all over the world. You only need pass through any street (on the Continent) to find a great number of visual signals applied as sign-boards by the different manufacturers or dealers in various articles viz., a boot, a pair of brass dishes, a piece of iron plate (meant to represent a piece of leather), &c. Although supplied with electric telegraphs, the railways always make use of visual signals as means of correspondence between the arriving or passing train and the stations or gatekeepers. The lanterns of a ship, the funnel-marks of steamers, &c., are so many visual signals, nay, even the flags, colours, and standards of the different nations, are visual signals, giving a certain amount of information regarding those who bear them.

Each of the signals, hitherto named, can convey but one single piece of information; every new communication that is to be sent requires a signal more, and very soon the number of signals will be too great to admit of a person remembering them all. A code, containing the meaning of all used signals, is composed, by means of which it is possible after a little practice to find out the meaning of any sign to be found in the code, or to dispatch any of the code's communications. A signal system of this kind, a "Code System," is inseparably bound to the code: the messages of the code may be forwarded quickly, but

¹ This treatise is somewhat altered from a paper read by the author in the Danish "Krigsvidenskabeligt Selskab" (Society for Military Science).

it is quite impossible to communicate anything that is not to be found in it, and when the code is not at hand, the system cannot be applied.

Whenever a code system has been developed to a certain degree of perfection, the number of messages becomes so great, that it is much too troublesome to have a special sign for each of them. We therefore take a few different signs or indications, which we can easily make, and we join them together in twos, or threes, or more at a time, making one after the other, into many and different and more complex signs or arrangements. Each of the original signs are called single, or primary, or elementary signals. The new signs made by joining these elementary signs together are called the combinations or combination signals. This already is the way to the other chief group of signal systems, the alphabetical; as, indeed, a similar proceeding is followed when we combine into words, the letters of a common alphabet. In an alphabetical system, the alphabet is often called "the code" of the system, but it differs essentially from the above named codes, in being so short and numbering so few characters, that it is easily learned by heart, and yet it permits any word of the language being expressed.

If visual signals are to acquire the same ability as the common written language to express whatever idea, whatever thought, presents itself to the mind, it is necessary to form them upon a common alphabet. The simplest thing would be to have an elementary signal for every letter of the alphabet, but as this would require a rather cumbersome apparatus, it is more common to apply fewer elementary signals, forming the letters as combinations. In fact a single elementary signal might be sufficient, the number of times it was repeated indicating the combinations; but this way of signalling would be tediously slow. It is more practical to apply two, three, four, or five elementary signals; most common is the use of two elementary signals, the combinations of which are formed upon the Morse alphabet.

Hitherto it has not been mentioned how the elementary signal itself is formed, as this is quite indifferent for the formation of the system. Any thing in existence, to which we can direct the attention of others, may be used as a signal. It may be a certain object, shown in whatever position, or it may be a certain position, as, for instance, the horizontal or vertical position of a spontaneous object, or it may be a certain movement of any object, &c., or several of these things may be combined, so that any position or movement assumes a different meaning as to the object that is used.

Considering the extensive use of visual signals in every day life, it might appear rather strange if they were not useful in armies. In fact every soldier learns certain signals, by which to communicate such tidings as most frequently occur, when on outpost, for instance: "Something suspicious," "Enemy in view," &c.; here we have a kind of code system, but a very imperfect one, and only fit for short distances. But the question is, whether a more developed system, fit for long ranges and requiring special means and drilled men, is sufficiently useful to armies to justify the incurring of considerable expense. And as the testimony of experience is the very best one, the

best judgment will be gained by considering to what extent visual signals have been employed and developed in the course of time, and what services they have rendered where employed.

Historical Review.

The use of visual signals of a primitive kind, especially of beacons and prognostics, can be traced up to the most ancient times. Thus the Tower of Babel was a kind of visual signal, destined to serve as a mark or rallying point for the surrounding population. A beacon, however, is a very imperfect signal; it only can convey one tidings: "To arms! the foe is coming!" but can tell nothing about who, or how strong the enemy is, on what point he is attacking, or where the muster-place is to be. Therefore the tidings of the lighted beacons were to be completed by a messenger, carrying further orders. The way in which these messengers were sent forward by the Scottish Highlanders and the ancient Scandinavians was thus (Walter Scott): "When a chieftain designed to summon his clan upon any sudden or important emergency, he slew a goat, and making a cross of any light wood, seared its extremities in the fire and extinguished them in the blood of the animal. This was called the Fiery Cross, also Crean Tarigh, or the Cross of Shame, because disobedience to what the symbol implied inferred infamy. It was delivered to a swift and trusty messenger, who ran full speed with it to the next hamlet, where he presented it to the principal person, with a single word, implying the place of rendezvous. He who received the symbol, was bound to send it forwards with equal dispatch to the next village; and thus it passed with incredible celerity through all the district. . . . At sight of the Fiery Cross, every man from sixteen years old to sixty, capable of bearing arms, was obliged instantly to repair, in his best arms and accoutrements, to the place of rendezvous. He who failed to appear suffered the extremities of fire and sword, which were emblematically denounced to the disobedient by the bloody and burned marks upon this warlike signal." During the civil war of 1745-46, the Fiery Cross often made its circuit; and upon one occasion it passed through the whole district of Breadalbane, a tract of thirty-two miles, in three hours.

Yet even this speed was not sufficient, the messenger was to be dispensed with; in other terms, the visual signal was to carry the entire message itself. It was no difficult invention to employ a greater number of visual signals, instead of one, the beacon; it was easy to add new signals whenever a new thing was to be communicated, and in this way complete code systems were soon formed. King Perseus had already communicated through whole signal lines with the most remote parts of his kingdom. During the Trojan war, the civilized nations knew, and made use of, more or less perfect signal systems. Thus the conquest of Troy was signalled to Argos, over a distance of 330 miles, and all over the Ægean Sea. When, in 479 B.C., Mardonius had taken Athens, he sent this news by fire signals, from one isle to another, over the sea to Xerxes, at Sardes. What kind of systems

these were, is unknown, but in the sea-battles of Cycicus and Mytilene the Greeks performed the decisive manœuvres upon orders communicated by an alphabetical signal system, an invention of Cleoxenes and Democritus. After this time, visual signals were frequently made use of in Greek and Roman wars, and they had special signal-troops, whose name, *πυρρῶται*, *i.e.*, fire-bearers or fire-shakers, indicates a signalling at night, and most probably by means of certain movements, perhaps similar to the swinging of the torches formerly used here. We owe the oldest of systems at present known to the Roman commander and author Polybius, who states that he had formed it by an improvement upon the systems of Cleoxenes and Democritus, and who used it during the first Punic war. The apparatus consisted of two groups of torches placed at a little distance from each other, and concealed behind a fence or screen. The Greek alphabet, arranged in five columns in the following way, was used as the code. The smaller letters are to show the English alphabet arranged after the same method:—

	1	2	3	4	5
1	A a	Z f	Δ k	Π p	Φ uv
2	B b	Η g	Μ l	Ρ q	Χ w
3	Γ c	Θ h	Ν m	Σ r	Ψ x
4	Δ d	Ι i	Ξ n	Τ s	Ω y
5	Ε e	Κ j	Ο o	Υ t	Ζ

Now to indicate the column where any letter is to be found, one or more torches are raised over the screen, in the one group, the number of the torches shown indicating the number of the column; at the same time torches of the other group are raised over the screen, indicating by their number the place of the letter in the indicated column. So to indicate in the third column, the second letter, "third," "second" is written, or there are shown three torches of the first group, and two of the second.

The Carthaginians also employed visual signals, and by this means kept up a communication with Sicily. It is related in the history of the siege of Agrigentum, that, although the town was perfectly invested, the commanding officer was signalling its condition over

the heads of the enemies, "by shaking (or 'swinging') through with "fire" (*εἰσπυρόμενον*).

During the middle ages visual signalling, like most of the civilization of the Ancients, was forgotten, yet it seems probable that a knowledge of it has been preserved in the East. The first time that it is again known to have been employed by European armies was during the siege of Vienna, in 1683, when John Sobiesky had marched to the rescue, and a certain John Smith in his army from the Kahlenberg opened communication with the besieged town over the heads of the Turks. Although there were several other causes, it is very probable that the defeat of the Infidels was partly owing to the co-operation of the besieged garrison and the relieving army, ensured by the signals of John Smith.

Visual signalling was not commonly employed until the year 1789, when the French engineer, Claude Chappe, invented his apparatus. On the top of a semaphore was suspended a long beam, with a shorter wing at each extremity. The different parts could be placed so as to form different angles between the wings and the beam, as well as between the beam and the semaphore. By a combination of the different situations of the various pieces, 196 figures could be formed, the meanings of which were to be found in a code. A telegraph of this kind was soon erected between Paris and Lille, about 130 miles. It made, as it were, its entry into history, by bringing to the convent the good news of the recapture of Condé from the Austrians, the same forenoon the town had surrendered. This form of telegraph was much used by Napoleon, who had many lines established, and it worked remarkably well; to such a degree indeed, that it was possible to forward a single signal from Lille to Paris within two minutes, and a short message from Berlin to the Rhine (480 miles) within fifteen minutes. A telegraphic apparatus, of somewhat different construction, was introduced into England, by Sir George Murray, a few years afterwards. A greater or lesser number of large wooden tables might be hoisted on a kind of scaffolding or system of frames. The number and situation of tables exhibited indicated the meaning of the signal which was to be found in a code. A telegraph of this kind was established between London and Plymouth, where it rendered valuable services during the great wars against France. The same telegraph was introduced in Denmark, in the beginning of this century, and a line was erected over the Great Belt, where the passing is in winter extremely difficult, and where it was of great value, until it was replaced by the electric telegraph.

The above telegraphs, however, were only fit for permanent stations, and all essays in making them sufficiently movable for field use did not produce the desired effect. Naval Officers, however, took these inventions in hand and improved and developed them, until a great degree of perfection was attained. The code of Sir Home Popham marks a grand progress. He represented each message by an arrangement of numerals, which might be sent to other ships by means of some twenty flags and pennants of different forms and colours, each representing a certain number. At night, coloured

lanterns were used instead of flags and pennants. Should the case occur that the message to be sent was not to be found in the code, it was possible by an agreed signal to indicate that spelling was to be used, and then to send any word, one letter after the other. Thus the system was to combine the advantages of the alphabetical systems with those of the code systems. This system was first introduced into Nelson's fleet just before the battle of Trafalgar, and made its *début* in communicating to the fleet the celebrated proclamation: "England expects that every man this day will do his duty." The superiority of this system over those formerly used soon caused its being adopted amongst all civilized navies, and somewhat later an English and French Commission composed an international code that by-and-bye came into use on board most large merchantmen. As it is not bound to any language, it enables the crews of any two ships to communicate with each other without understanding a word of each other's language. The honour of this meritorious work is principally due to the Englishman, Mr. Larkins, and the French Lieutenant M. Sallandrouze de Lamornais. But all these systems were too cumbersome for field-service, requiring a large apparatus and especially a high pole that could not always be at hand or easily and quickly raised; and it was only on board ship that they continued in use after the electric telegraph had banished all visual signalling from the Continent. Yet it was by-and-bye discovered in the armies, that even the electric telegraph has its deficiencies and its limits and cannot satisfy all wishes, and that it fails just in such cases where a good signal system would be of use. Several attempts were made to devise a good one, fit for use in the field. A French Count, Pouget, "*Capitaine de frégate en retraite*," lays claim to having invented a practical system by a simplification of that used in the navies, and by diminishing the number and size of the flags so that a horseman could not only carry the whole apparatus with him on horseback, but could even exhibit the signals while in motion. This appears very tempting, but as Captain Pouget keeps secret all further details, such as the way the flags are displayed, the ranges at which they can be seen, the rate at which the signalling is carried on, &c., it is impossible to form any trustworthy opinion as to its usefulness when compared with other systems. Yet it ought to be observed that signalling, being carried on while the signallers move, the signals are to be read with the naked eye—therefore on short ranges—and that the system, being a code system, is less perfect than an alphabetical one. As far as I have been able to ascertain, this system has not been practically employed in any army.

It was the American Colonel (afterwards General) A. J. Myer, who was the inventor of veritable Field-Signalling. He devised several alphabetical systems formed of a various number of elementary signals, but seems ultimately to have preferred one with but two elementary signals as most fit for field use. Colonel Myer made great use of his signals during the war between the United States and Mexico, as well as in several Indian campaigns, and they were, during the great civil war between the Federals and Confederates, employed upon an extensive

scale. But Colonel Myer no longer had the advantage over the enemy in alone employing visual signals, for, unfortunately for him and his party, one of his former subalterns, having learned his system, joined the Confederates and introduced it in their armies, so that both contending parties vied with each other in deriving the greatest possible advantage from their visual signals.

The signal staff, of hickory, was made in four pieces, each 4 feet long, and tapering as a whole from $1\frac{1}{4}$ in. at the butt to $\frac{1}{2}$ in. at the tip. The joints were ferruled at the ends with brass, and fitted to be jointed together. When in use two or more joints of the staff were fitted together.

The signal flags were made of some light and close fabric, and used of three different sizes, viz.: 6, 4, or 2 feet square. They were either black or red, having in the centre a block or square of white, or they were white, having in the centre a block of red. The breadth of the block was one-third of that of the flag. At night torches were used, one, the flying torch, to fix on to the signal staff, another, the foot torch, to place on the ground, as, without a fixed point in view, it cannot be distinctly traced to which side the flying torch is moving. The torches were copper cylinders, filled with turpentine, petroleum, or other burning fluid, and furnished with a wick of cotton.

The signals were observed and read with the aid of a binocular field-glass or telescope. When signalling was to begin, the flagman raised the flag or torch directly above the head. The motions "one" or "two" were performed by waving the flag directly to the right or left side until it touched the ground and bringing it at once back to the first position. The "one" and "two" of the visual signals were to represent respectively the dot and dash of the Morse alphabet, so that any telegrapher might be employed at signalling nearly without any special training. The different motions belonging to the same letter were performed without stopping, for instance, d=211 by a wave of the flag to the left, thence, without stopping in the vertical position, immediately over to the right, thence to the vertical position, thereupon at once down to the right again and thence back to the vertical position, where it was to stop a moment before beginning a following letter.

These signals were generally used at 10 or 12 miles' distance; communication is said to have been had at 25 miles, and detached words are reported to have been read at 40 miles' distance. The following examples will give an idea of the results attained during the Civil War.

In 1863 the Federal army under Hooker passed the Upper Rappahannock, intending to attack Lee's left while a corps of 40,000, under Sedgwick, passed the lower river at Fredericksburgh. But Lee guessed their intention, threw himself between the two parts of the northern army, defeated Hooker at Chancellorsville, and turned upon Sedgwick, who was in great danger of being cut off from his bridges. But he was saved by his signal communication with the troops on the northern bank from which a telegraph led to the head-quarters of Hooker. Being informed of Sedgwick's dangerous position, Hooker, by a renewed attack, procured him the time to repass the river.

During Porter's attack of Fort Fisher in 1864, the landed force observed the effect of the firing from the fleet and, by communicating through signals the result of their observations, enabled such precision of the fire, that most pieces of the fort were soon silenced, and the crew could scarcely stir from out of the casemates. This was the chief cause of the easy success of an attack, that a short time before had been so completely beaten off.

When, in 1864, Sherman had occupied Atlanta, Hood, by a quick manœuvre, tried to cut him off from his lines of supply and attack his base at Allatoona. Hood was already so near Allatoona, that it would have been impossible for Sherman to come to its assistance in time, had not the chief of his signal corps, Captain Bachtal, succeeded in approaching sufficiently near to the 50 miles distant Rome, to order General Corse to the assistance of Allatoona. Corse, with a brigade, reached Allatoona in due time, but a mishap with an engine stopped the rest of his troops, and soon the whole army of Hood made its appearance. The first attack was happily beaten off, but still the danger of being overpowered was imminent, when suddenly something was seen to move on Mount Kenesaw, at 18 miles' distance. It proved to be the signallers of Sherman's army, and the news of the approaching assistance highly elevated the courage of the defenders: the reply sent by Corse, that he held his own, and would continue to do so, was not less welcome to Sherman. He had marched to the rescue with all possible speed, and in front of his army, with the foremost cavalry patrols, signallers hurried on from mountain-top to mountain-top waving from each of them their flags, until communication was established. Hood was obliged to beat a hasty retreat into the Alleghany Mountains.

At a later period, when Sherman, having finished his grand march through Georgia and Carolina, gained Savannah, near the Atlantic, his signal corps had communication with the Federal fleet on the same day that the army had carried the fort McAlister, and thus gained a firm footing at the sea-coast.

General Gillmore had, during the siege of Charleston, by means of a signal line of 55 miles with seven stations, established communication from his head-quarters to the different army corps as well as to the fleet. As the country was woodland and difficult to overlook, it was necessary to erect some signal stations on high scaffoldings, some of which attained a height of 138 (after other reports 160) feet by 30 feet square base. This signal line rendered valuable services, although it was a terrain where a part of it ought rather to have been furnished by the field telegraph.

General Early, during the winter 1864-65, lay in Staunton, and had against him Sheridan, at Winchester. But Early had left before New-market cavalry detachments, with which he maintained telegraphic communication, and which had, by advanced patrols, established signal stations in Ashly's Gap, on the northern side of the Massanutten Mountains, and even in the lower Shenandoah valley in the enemy's rear, so that they overlooked his camp with all its environs. By this means Early at once was informed of any operation against him

by Sheridan, though they were at 90 miles' distance from each other.

Visual signals were not much employed in the wars of 1866 and 1870; they were, however, used at the sieges of Belfort and Metz, where the available field telegraph *matériel* was not sufficient. Neither do they seem to have played any pre-eminent part during the Russo-Turkish War, though many a time the contending armies had to feel bitterly the want of such a means of communication. It is only necessary to call to mind the battles in the Shipka Pass, as well as the first rencontre at Plevna, which would probably have taken another turn, had it been possible sooner to have called to aid the supporting forces; whereas the Russians took great advantage of their field telegraph in the campaign against Moukhtar Païha, though the communication with the turning column through a field telegraph line must needs have been in great danger of interruption, and a signal line here would have been less endangered.

The Austrians, during the late campaign in Bosnia, made use of visual signals to a great extent, and, indeed, without them, would not have been able to keep up the needful unity of operations.

The system employed was the "clock-vane system" of Lieutenant-Colonel Yonge, of the English army, which is also used in Italy. It consists (such as used in Austria) of a pole, 6 feet in height, at the top of which is a triangular wing of 5 feet in height with a base of 3 feet, a smaller triangle being cut out of it in the middle. It can be shown in twelve different positions, which number is redoubled by hoisting a "point" over the triangle or omitting it. The "point" is a circular disc of 2 feet diameter, a smaller circle being cut out of its middle. The twenty-four signs represent the twenty-four letters to which the alphabet may be reduced.

According to the accounts of Austrian Officers, signalling was carried on at distances of 8 or 9 miles; but here it ought to be observed, that they possessed telescopes of very superior quality, and that the air of the southern climate and those rocky heights is much more transparent than in our hazy country. The conclusion therefore is, that, under equal circumstances, this system can hardly be used at so long distances as the flag system. Indeed, it would appear very strange if the above described triangle and disc, being much smaller, should be more visible at any long distance than a 4 feet square flag, which is waved, moreover, as it is generally acknowledged that—

"Things in motion sooner catch the eye,
"Than what not stirs."

SHAKESPEARE.

As to the rate at which signalling can be carried on, I have not been able to find the desired data, but it seems scarcely credible that, under ordinary circumstances, each letter might be shown by the one station, recorded and repeated by the other, and changed in much shorter time than four or five seconds, which should be the case if the quickness of this system was to prevail over that of the dot and dash system, with 4 feet flags. The clock-vane system, it is true, may be

somewhat easier to learn, and especially to remember, by such as do *not* use it every day, but it is more difficult to extemporize the *matériel*, and it is less fit for use on intermediate stations, being less able to change the front. It appears certain that the clock-vane system is a very ingenious and useful signal system, but scarcely superior to the dot and dash system with flags; yet it is impossible to judge with full certainty of the matter without having tried both systems under equal circumstances, and assisted by equally trained men.

During the last few years the English above all others have developed and made use of visual signals. A small flag has been introduced for short distances, and by it messages are said to be sent at a minimum rate of ten words per minute. This flag gives the advantage over signalling to mounted orderlies, even at short distances. But a still greater improvement is the invention of the heliograph. As it was exhibited and explained at the Royal United Service Institution last year by Major Wynne,¹ I shall not here enter into any details as to its construction. This wonderful instrument has often sent its messages to distances of 25, 30, or 35 miles; it has been tried to ranges of 50 miles without telescopes, and one memorandum even states that signals with a 6 or 8-inch mirror have been seen with the naked eye at a distance of 100 miles. At night the instrument has been employed as a "selinagraph" (using the moon's rays), and the signals were discerned with the naked eye at 12 miles distance; at short ranges even the light of a planet has been used; but it must be remembered, that all the above-mentioned feats were performed in southern and sunny countries.

The immense services rendered by the heliograph during the campaigns in Afghanistan and Zululand are certainly so fresh in the memories of the readers, that it is useless to repeat the circumstances of the different cases. Few who have heard or read the account of Major Wynne will deny that the heliograph has been of inestimable value to the British cause and has saved thousands of brave soldiers from disaster.

It would be easy to name, besides so many instances of valuable services rendered by signals, a still greater number of cases where the want of a similar means of communication has been most bitterly felt. Thus the defeat of the insurgents in the Battle of Idsted would certainly have led to the capture or destruction of their whole force if the Danish Brigade Schepelern, who had completely turned them, had been in signal-communication with the Commander-in-Chief. The defeat of the French at Waterloo would, on the contrary, scarcely have been so complete had Napoleon, by a signal-communication with Grouchy, been informed in time of the fact that this General had been outwitted by Blücher, and that it was the latter, not the former, who was arriving on the battle-field in the afternoon. Indeed, there is hardly an Officer who has seen service who cannot call to mind scores of instances in which it might have contributed to the success of an expedition or engagement, if he and his fellow Officers had only possessed so much skill in signalling as may be acquired by a few hours' practice.

¹ See Journal, vol. xxiv, page 335, *et seq.*—Ed.

Development of Signalling in Denmark.¹

During the wars of 1848-50 and 1864, especially during the first, signal lines were erected and were of use, but the systems applied were only fit for stationary lines; it was no real field signal service. In 1868, the "First Battalion of Engineers" caused a *matériel* to be extemporized, and with this, during the ordinary camp, in the same summer, the dot and dash system was tried with flags and torches. As the trial had a satisfactory result, the *matériel* was by-and-bye completed and formed of flags, petroleum torches, and flashing lanterns (*Blinklanterne*). As for the flags, only two patterns were used, one red with a white block, another white with a red block, both of 4 feet square in size. It was considered useless to have larger flags, as the 4 feet flag is quite sufficient at the distances that our climate permits. Experience has shown that, on light backgrounds, the red-white flag shows more clearly than a black-white one, so no black flags were procured; but it is probable that, for use on short ranges, 2 feet or 1½ feet flags ought to have been procured besides the 4 feet ones. The torches were principally used as in America, being waved as the flags; they were sometimes also placed on the ground and alternately obscured and exposed so as to mark the dots and dashes by flashes. But we were not satisfied with them, as they did not burn sufficiently constantly, and were too much influenced by the wind. The lantern was a lens-lantern with an oil lamp in it, and a screen to hide the light. By lifting the screen, short or longer flashes, representing the dots and dashes of the Morse alphabet, were produced. The lifting of the screen is operated by means of a small handle, similar to the Morse key, but takes so much time that even the dot is of some length, and as the length of the dash ought to be the triple of the dot, signalling becomes too slow for the short distances—one or two miles—at which the lantern can be used. Therefore it has found but very little application, though it is still forming a part of the equipment. For observation, telescopes, on tripod stands, were used, and for scanning the surrounding country, each station was supplied with binocular field-glasses.

Upon the whole, the day signals were found to work satisfactorily, only their use was improved by practice, as were also several parts of the Manual of Instruction. Thus, instead of using three pieces of the rod (which is much like the above described American one), the flag is now almost always used with two pieces only, and this 8 feet rod has been sufficiently evident even at ranges of 4 or 6 miles. Any signaller, and, indeed, any one knowing the laws of a pendulum's movements, will understand that signalling can be carried on at a much quicker rate—in fact the double—with an 8 feet rod than with one of 12 feet. The rules for signalling are now, in short, as follows: Whenever a word is finished, the flag man at the sending station twice elevates his flag as

¹ Though the following was written especially with reference to Denmark, it has not been thought right to omit it here, as it, in the present somewhat shortened and altered form, might be of interest in any country with an insular climate like our own, by the adduced data from our practice in signalling.

high as possible, each time immediately lowering it again to the normal position. Each word is to be acknowledged by the receiving station by "understood" (the flag is lowered to the ground in the direction of the sending station, and at once raised again) or by "not understood" (six "ones"). Formerly the whole message was sent before any reply ensued, but, in case of misunderstandings, the new method saves much time and trouble. If intermediate stations are employed, they send on the message, letter by letter, as soon as each letter is received, to the receiving station, from which the "understood," or "not understood," after each word is repeated by all intermediate stations until it arrives at the sending station. Any word replied to by "not understood" is of course to be at once repeated by the sending station.

In case a message should be observed by an enemy, a part of it can be sent in cipher. For enciphering a message, Wheatstone's Cryptograph is used. It is a cipher wheel, in appearance similar to that shown in the (English) "Manual of Instruction in Army Signalling," consisting of an outer and an inner circle with letters. Round the outer circle the twenty-six letters of the alphabet are placed in usual order, and one place is empty, the circle containing twenty-seven places. The inner circle contains only twenty-six places in which the letters of the alphabet are placed in any spontaneous order, different from the usual one. An arm, reaching to the outer circle, and a vane, reaching to the inner one, are fastened to a pivot in the centre. The arm wears a cog-wheel with twenty-seven cogs, and the vane another cog-wheel, having only twenty-six cogs. Both cog-wheels work in the cogs of a third cog-wheel, placed near them on an independent axle. If now the arm is moved on from one letter to another, its cog-wheel following the movement is turned so much round as the breadth of one cog, it moves the loose cog-wheel, and this again moves the cog-wheel of the vane just as much, viz., the breadth of one cog, and this, being firmly combined with the vane, moves it on from one letter to the following. When the arm has made a complete revolution, any point of the disc, near the circumference of the cog-wheel, has been passed by 27 cogs, consequently the cog-wheel of the vane has also been turned as much as 27 cogs, but its circumference only has 26 cogs, so it has turned quite round, and one cog more, which is to say, that the vane itself has made a complete revolution, and has still passed on one letter further. Suppose the arm points to the empty place, and the vane to any letter, for instance, *d*. If the arm is moved once round and points again to the empty place, the vane does not point to *d*, but to the letter succeeding *d* in the inner circle. So, whenever the same letter is repeated in the original message, it will be represented by a different letter in the cipher message, which renders the deciphering of some intercepted message very difficult, while at the same time the use of the cryptograph is so easy that, without any difficulty, all privates of the telegraph company are taught how to employ it.

Now, to encipher a message, put the arm on the empty place and the vane on the "key letter," beforehand agreed upon; move on the

arm to the first letter of the message, look where the *vane* is pointing and write down that letter, move on the arm to the second letter of the message, and write down the letter at which the vane is now pointing, &c. The deciphering of a message through the cryptograph is just as easy. Place the arm at the empty place, and the vane at the key-letter; move on the arm till the *vane* points at the first letter of the received cipher message and write down the letter at which the arm is then, &c.

Sometimes a message has been enciphered at the sending station by one man, whilst it was sent off by another, and at the receiving station it was deciphered as quickly as received, without any loss of time; but ordinarily a little time has to be spent in enciphering and deciphering. Cipher messages are always repeated by the receiving station, and some other detailed rules are given for the practice with the cryptograph.

As the night signals were not satisfactory, several other means of night signalling were tried.

The Chatham light is a very brilliant one, produced by combustion of the "Chatham powder," a mixture of magnesium, resin, and lycopodium in different proportions, according to the power of light required. By means of a pair of bellows, a sharp current of air is produced, and it blows a jet of the powder into the flame of a spirit-lamp, where it becomes ignited, and produces a flash, lasting till the current of air stops. But the burned powder does not entirely disappear, the remains partly fall down to the bottom of the lamp and partly cleave to the glass, so that it becomes less transparent when the lamp has been worked for some time, which renders the light less brilliant, and causes some difficulty in discerning the length of the flashes. On account of these causes the lamp was not entered into our equipment.

Walker's Lime-Light Lamp was then tried. Here a lime pencil is heated in the flame of a spirit-lamp, reinforced by a current of oxygen. The lime becomes white-hot and gives a very brilliant light. The flashes are produced by elevating and lowering a screen. The lamp was deemed fit for permanent stations, and the adoption of it for those was proposed to Government; but for field signalling it was not recommended, out of fear that the producing and transport of oxygen in the field might cause some difficulty, and that the gas-bags might not be able to stand being exposed to the change of weather and ill-use, inseparable from field service.

At last, in 1877, we succeeded in finding a means of night-signalling, that was deemed tolerably satisfactory for use in the field. It was Spakowsky's flashing lantern,¹ which had already at that time been introduced into our navy for use for signalling with stations on shore. After having been repeatedly tried, and after having received several improvements, this lantern was adopted by the Telegraph Company. A small spirit-lamp, invisible from without, is constantly burning in the lantern, when in use. By means of a pair of bellows and an apparatus similar to the well-known flower syringes (*rafraî-*

¹ See Journal, vol. xi, No. XLVII, page 658, *et seq.*

cheurs), a steam or drizzle of petroleum can be blown into the spirit-flame, where it is ignited, and burns with a brilliant blaze, 1 or $1\frac{1}{2}$ ft. high, until the current of air from the bellows ceases. The length of the flash is regulated by the mechanism of the apparatus, so that a dash is equivalent to three dots. The signals of this lamp have been read with the naked eye at a distance of 14 miles, and at a distance of 4 miles the lantern has been employed with great success during a rather heavy rain. On shore the lantern is placed on a tripod stand; on board ship it is usually fastened to a pole, supported by a man.

The *matériel* belonging to a signal station was originally taken along on an ordinary waggon; but as it suffered much by the transport on rough roads or over fields, and by being loaded or unloaded so very often, a box for this use was constructed, in which every object was either put into a special compartment, where it fitted closely, or strapped tightly to the proper place in the box. These boxes, however, being very large, heavy, and cumbersome, a signal-station carriage of a peculiar pattern, very light and singularly fit for passing obstacles and accidental terrain, was constructed in 1876. After having been tried several times, and after having received several improvements, it was adopted as the normal carriage for a signal station. It consists of two parts, limbered together in a fashion similar to that employed with field-guns. Each half-carriage is fitted with a box like the above-mentioned, some 4 ft. long, 2 ft. broad and high, containing *matériel* for a single, or terminal station, the double of which is adopted as normal for a complete, or intermediate station. This way of dividing the *matériel* has the advantage that, in cases where great ease and mobility is required for a terminal station, for instance, if it is to follow a cavalry raid, the fore-carriage alone may be used. On each box are seats for three men, and behind the seats there are hooks and straps for the fastening of kits and carbines. The carriage is drawn by two horses. The Officers and the elder non-commissioned officers are mounted.

This complete development of the signal service has been brought out by the Telegraph Company (Royal Engineers), originally destined only for the field telegraph service of the army. Thus the creation of a signal company, or of an extra telegraph and signal company, is much wanted; it has long been desired, and was last year by the Government proposed to the Parliament, which latter, however, refused to vote the necessary expenses.

There is another fact that has often been an obstacle to signalling practice, viz., the want of horses, for the Engineer Corps has no horses of its own, but is directed to apply for them to the artillery, when wanted. This occasions that every practice in signalling or telegraph service is to be pre-arranged several days before it is to take place, which is a serious inconvenience.

Observations on the use of Visual Signals.

If a visual signal corps is to fulfil its duty completely, it is necessary not only that the corps itself is sufficiently able and well-drilled, but also that the commander, at whose disposal it is placed, is perfectly

acquainted with its abilities, its advantages and disadvantages, so that he knows how to employ it.

As to the signal corps, every man ought to be fully trained in sending messages with flags and the other means in use, in managing and using the telescopes, enciphering and deciphering messages by means of the cryptograph, and, last, but not least, he must know the signal alphabet by heart, just as well as the common letters. Whoever can be entrusted with leading a signal station, ought to possess the same accomplishments, and, moreover, must be able to find his position quickly, even in an unknown and difficult country; he must have a good apprehension of the terrain and the ability to find out without much loss of time where other stations are placed. These qualities are far more difficult to acquire than most people suppose; much experience and practice in the field is necessary. A signaller ought to be a perfect soldier, vigorous and able to suffer hardships, but of all bodily accomplishments, none is more needful than a keen and long sight, without which no man should ever be appointed to signal service.

Yet even with the best-drilled and most skilful troop, much loss of time may be caused by the laziness, ill-will, or negligence of a single man, and often it may be extremely difficult to point out who is the guilty one if faults are committed or delays occasioned; indeed, much depends on the good will and zeal of every private, therefore the *morale* of the troop ought to be of the very best; it must be brought to such a point, that each man puts his honour into the performance of his duties with the utmost possible celerity and accuracy. An Officer who does not understand how to inspire into the minds of his subalterns the highest degree of emulation and self-devotion, may be very able to command other troops, where obedience can be enforced, but should never be employed in signal-service.

As to the other point, the acquaintance of the superior commanders with the signal service, it has been but too often disregarded. If a signal corps is placed at the disposal of a superior Officer, unacquainted with its use, he will exact either too much or too little of it; in the first case the signal corps will not be able to satisfy his expectations; in the second, it might do more, but will have no opportunity fully to display its usefulness; in either case the commander concerned will form a false opinion of the signals, without observing that, by his own fault, the signal corps was not used as it ought to be. At other times you will see a communication by visual signals employed, where a field telegraph line would better do, or *vice versâ*. But while literature is so destitute of directions and practical hints as to the use of visual signals as is now the case, such knowledge as is required can only be obtained by personal experience and practice in the application of this new apparatus.

A signal station must be situated near the commander at whose disposal it is placed if it is to be of the greatest possible advantage to him. As its place cannot be chosen spontaneously, but depends on the terrain, the commander will often be obliged to have regard to this, in choosing his own place, which may be a little inconvenient,

as there are many other views to be considered ; yet it is an advantage, that signal stations are nearly always erected at good look-out points.

He who wants to employ visual signals to the greatest advantage ought to pay attention to two things principally : the distance at which signalling can be seen, and the rate at which it can be carried on.

The distance depends upon the transparency of the air, the skill and practice of the signallers, and the apparatuses employed.

It is a matter of course, that all visual signalling is rendered impossible by a dense fog, a heavy rain, or thick snow. That is the chief disadvantage of visual signalling, and is always adduced by the antagonists of the service as a proof of its uselessness. But have not the visual signals of navies, or even its lighthouses, the same shortcomings, since they are invisible when the sailors stand most in need of their guidance ? And yet nobody thinks of abolishing them ; they are, on the contrary, constantly improved, and their number is augmented. In fact, however, this disadvantage of visual signalling, though great, is by no means so decisive as it might appear at first sight. In the first place, it must be remembered that the other means of communication are also dependent upon the state of the weather ; the same weather that is an obstacle to visual signalling causes great difficulties to the orderlies finding their way, and even the electric telegraph may be destroyed by storms, or rendered useless by thunder. In the second place, the said inconvenience is partly attenuated by the fact, that he who is to make use of the communication by signals always may know beforehand when it is useless, or in any case may be very soon informed whether his message will reach its destination or not ; whereas he will be uncertain whether a detached orderly has fulfilled his task until the orderly has returned again. In the third place, it ought to be well observed, that a complete interruption of signalling, even in our climate, does by no means take place so often as is commonly supposed ; but whether the state of the atmosphere is to be considered transparent or not depends in an astonishing degree on the signallers' skill and ability. When, in a semi-transparent atmosphere, a man without practice sees the flag so indistinctly that it disappears out of his sight every other moment, and renders the observation of its movements quite impossible for him, an able and practised signaller will read message after message without failing ; and practice is of still greater importance for night signalling, when the length of the flashes are to be judged. Any signalling officer with some experience in the matter of instruction can testify to what an astonishing degree the difficulties caused by a thick atmosphere are diminished by-and-bye, as the practice and skill of the signallers increase. Signalling at 4 or 5 miles distance has often, without any serious difficulty, been carried on through an ordinary rain. Last autumn we signalled for two hours without any interruption between Lyngby and Thinghøj, a little more than 4 miles, though it rained so hard that we were all wet to the skin, and some had their top-boots full of water before we stopped. During the camp last summer, signalling was practised twenty times, thirteen times out of which it was continued a part of the night, and

a few times all night long, till the following forenoon. Out of these twenty signalings, one, a single one, was completely interrupted for several hours by a fog, and another for a quarter of an hour by the morning haze, and the smoke of gunpowder. Four times there fell some rain during the practice, without influencing it in any considerable degree. The distance between two neighbouring stations was generally between 4 and 7 miles. Another inconvenience that diminishes the transparency of the atmosphere more frequently than fog or rain, is the hazy glittering or quivering of the air, which, in our country, nearly always accompanies sunny weather; yet it will seldom thoroughly prevent signalling at distances under 7 miles, when the signallers are well trained, and the background is judiciously chosen, although the air is often less transparent during a sharp sunshine than during a slight rain.

Different instances have been previously mentioned of the enormous ranges at which signalling has been successfully performed, but this took place in other climates, where the pure and serene air affords far more favourable conditions for signalling than our hazy skies. Indeed, it cannot be absolutely denied but that there may also be days here on which signalling at wide distances may be possible, and it would be interesting to know the maximum distance possible under the most favourable circumstances; but in consequence of the great difficulties that signalling has had to surmount here, it has not yet been possible to gather sufficient experience upon this matter. Although such experience might be very interesting, yet a perfectly serene atmosphere is so seldom, and commonly of so short duration, that such wide distances as require a similar weather can only be used in a few exceptional cases; therefore distances approaching to the maximum ought never to be employed, unless circumstances make it absolutely necessary. This would only cause frequent interruptions and disappointments, and give credit to the charge of untrustworthiness, so often laid against visual signals. If this charge is to lose all real cause, it is necessary to lay the foundations of signalling on such short distances, that it may be carried on uninterruptedly, should even the atmosphere become somewhat hazy and quivering, or should there fall some rain. Only experience can decide how large these distances may be; with our actual *matériel* they can safely be made from 5 to 7 miles; but it ought to be observed that the telescopes employed are scarcely so good as they ought to be, and if they are improved, it is very possible that the distances can be made larger.

When the distance between two stations is rather wide, it is of the greatest importance that the backgrounds are well chosen, and the telescopes firmly placed. Uniform backgrounds with distinct, clear colours, very light or very dark, are the best ones; for instance, the sky, dark woods or heather, newly ploughed fields with a blackish soil, light green fields, white walls, &c., whereas broken backgrounds with indistinct and mixed colours like most houses, ripening corn, or stubble fields, &c., are very bad ones, and do not contrast distinctly with any flag.

If the telescope quivers ever so little, the distinctness of objects seen through it is much obscured; therefore it is to be placed safe from the wind, on the lee side of some hill or other elevated object; if, however, the wind is blowing directly from the other station, this is not possible, but nearly the same result is attained by placing the telescope directly before the said object—to the wind side—where the air is, so to say, stowed up and the wind scarcely felt.

Although the flash of the Spakowsky lantern is visible at far greater distances than the signal flag, yet the greater distance renders it more difficult to distinguish between the dash and dot; and as night stations must be established beforehand, and during the day-time, it will in most cases, with regard to practical causes, be preferable to use the same stations by night as have been used by day, perhaps with the sole exception, that a signal line of a length of 9 to 14 miles may, during the day-time, be served by three stations, while, at night, the intermediate station may be omitted, and signalling carried on directly between the two extremities of the line.

The quickness of the signalling especially depends on the skill and zeal of the signallers, and of the apparatus in use, though it is also influenced by the weather and distance. The more clearly and precisely the signals can be seen, the fewer mistakes and accidental losses of time will occur, and the greater will be the celerity attained. In our Telegraph Company, the ordinary rate for signalling between two stations is now between two and three words a minute with flags, and between one and two words with the lantern. Each station added to a line will delay the messages a little. This appears very slow in comparison with several statements from other quarters. But, be it observed, that this is the medium of a great many messages, sent while drilling the signallers, who the first times wanted more practice, and that the time is reckoned from the moment a message was begun until the last word was accepted by the receiving station, and the message ready for being forwarded to its place of destination. This is then the real average time that messages have been on the line, all loss of time by misunderstandings, and all time elapsed with pauses, &c., being comprised in the above-named time. Some knowledge of the quickness of signalling is indispensable to those who are to make use of it; for each useless word causes a loss of valuable time, and it is of the highest importance to make the messages as short as possible, especially where the distance is short, or else the message might be sent more quickly by a mounted orderly. Certainly signalling can be developed so that it may be conducted at a somewhat quicker rate; but when Major Le Mesurier has stated that, with the small flag lately introduced into the British army, a rate of ten words or more per minute is attained, he probably means only the time necessary for performing the signals at the sending station, without considering the delays and pauses indispensable in real signalling, so that the expedition of a message will, indeed, take somewhat more time. But if we bear in mind the fact that most messages might be finished within two or three minutes, even a rate of five words per minute will ensure the swiftness of signalling being superior to that of mounted orderlies at

any range from a mile and upwards even for a single message, and the more so when the number of messages is increasing. When the telescopes are of the best quality, it appears very probable that a much smaller flag than one of 4 feet may be employed at such ranges as our climate admits of, the more so, as it is easier to wave a little flag than a large one and so quickly that it presents its full size in whatever direction the wind may be blowing. The statement of English Officers, that signals are the more clearly seen the quicker the flag is waved, has been fully confirmed by experience in the Danish Telegraph Company.

Well-drilled signallers will carry on signalling through two or three intermediate stations almost as surely as between two stations, though somewhat more slowly, so we are enabled to extend a signal line over a distance of 19 to 30 miles. If a greater number of intermediate stations be employed, the line can be made still longer, but the probability of mistakes will increase; and by the actual development of the field telegraph, as well as of the permanent telegraph lines, it will scarcely ever be needed or advisable in our country to extend a signal line over a larger space. Most frequently the signal lines will be limited to a length of 10 or 18 miles with one or two intermediate stations, the electric telegraph being employed at wider ranges.

What distance should be regarded as the minimum length of a signal line depends on several circumstances, such as the rate at which signalling may be carried on, the length and number of messages sent, and the number of mounted orderlies at disposal. In this case it is the distances that the orderlies have to surmount, not the line of vision, that is to be considered. At the above-mentioned rate of two or three words per minute, the signal communication will be superior to orderlies, for short statements of five to ten words, at ranges of 2 or 3 miles, while orderlies may be preferable for messages of twenty-five or thirty words, at distances of 3 or 4 miles. If no mounted orderlies are to be had, a signal communication may be of great use at ranges of a mile. What has been said here refers to a single message only; if many messages are to be sent with short intervals, signalling will maintain a superiority even at somewhat shorter ranges.

Whilst the most proper zone for signalling thus lies between 1 and 4 miles' distance, it is relieved, at longer ranges, by the electric telegraph, and, at shorter ones, by mounted orderlies; but as the proper employment of all three means of communication depends on many other circumstances, there may be cases where the electric telegraph ought to be employed at shorter ranges, which are mentioned as suitable for visual signals, or that mounted orderlies ought to be employed at longer ranges than above-mentioned, or, perhaps, that visual signals ought to be employed at ranges commonly better fitting for one of the other means of communication. In any case visual signalling is, indeed, indispensable if there is impassable terrain of rather wide extent or hostile troops or inhabitants between the two points that are to be connected. They are, therefore, so frequently employed at sea and are an inestimable means of communication

between the army and navy, where both are to operate in concert. Other circumstances of consequence for the employment of visual signals are essentially different, inasmuch as the troops that are to make use of them, are—

1. In motion.
2. In positions.
3. In fight.

1. The army is moving. In this case there is a great difference between those lines of communication that are leading parallel to the front, that is to say, lines combining the different columns, marching in the same direction on various roads,—and the lines following the direction of the march and leading from the advanced parties of troops back to the main force. Both sorts of communications claim a considerable degree of mobility and swiftness; in the first case, an orderly will always have a much longer way to ride than the direct distance between the columns, the more so as these may often be separated by pathless, or small pieces of impassable terrain; in the second case, he will certainly be able to get quickly from one party to another as long as he moves in a direction contrary to that of the marching troops, but will be very slow in returning when he is to overtake and speed past them. For these causes signalling may be employed at short distances without being inferior to a communication by orderlies.

The electric telegraph will scarcely be well placed during the march; for even if the setting-up of the line be carried to such perfection as to follow the troops on their march, yet a station cannot be erected and earth-conduit established without some stoppage and delay. Still the telegraph may in certain cases be employed for communications along the road which a column is taking, where one station may stand still, but it is not possible to establish and maintain an electric communication between two columns in motion. The stations only can be established on preconcerted places or at preconcerted hours; the communication is interrupted while the motion takes place, and if one column meets the enemy the others can have no tidings of it. In fact it has been tried to keep the telegraph station wagons in constant communication, forming the earth conductor by the wheels touching the ground; but a very dry road is so good an insulator, that no current will pass. The only means of maintaining telegraphic communication between troops in motion would be employing a cable with two separately insulated wires. But cables are, on account of other causes, more and more abolished by the field telegraph. Thus, communication is during the march, especially in directions parallel to the front, chiefly to be maintained by visual signals.

One of the most difficult tasks that can be given to the signallers, is that they are to maintain a constant communication during the march between the different columns, and at the same time between the vanguard and main force of each column. If this task is to be performed to perfection, signalling must be possible during the movement. This is the case with the system of Pouget, but, on the other hand, the distances between his signallers are exceedingly short. Strictly

speaking, our *matériel* is not constructed with a view to signalling while in motion, yet it is by no means impossible to do so, and it has, indeed, been tried with success to send off messages with flags from the moving carriage; only it must be remembered, that the signals have to be read with the naked eye, as the jolting of the carriage prevents the use of a field-glass; therefore in this case the distance can scarcely exceed some 2 miles. If much is to be signalled, or if the distance is too great to permit observation of the signals with the naked eye, stations are to be established at proper places. A station is established within a couple of minutes, but sometimes there may be some delay ere communication is had. If, therefore, signal parties are to give full satisfaction during the march, it would be preferable that each of their respective commanders whom they are to serve had two completely equipped signal stations at his disposal, so that they might move on alternately, one of them always being stationary and having communication while the other is moving. As it is of the highest importance, when the army is in motion, that communication be established without any loss of time, and signalling carried on with the utmost possible speed, moderate distances—some 4 or 5 miles—are to be recommended for this case.

2. When the army has for some time held a *position*, it may be supposed that there will always be set up field-telegraphs between the permanent lines of the country and the head-quarters, as also from these last to the different army corps and divisions, perhaps even down to the brigades, and from them to their battalions on outpost; some have even planned an extension of the telegraphic net by means of the outpost telegraph, and the telephone to the videttes themselves. In any case the establishing of a telegraphic net of such perfection will require a certain degree of tranquillity in the position and a vast *matériel*, so it may be supposed that the electric lines will often stop at the divisions, at least on some places; thence to the outposts the communication in such case ought to be established by visual signals. But even with the most complete telegraphic net, there still remains sufficient room for those; their real activity is to be displayed in the most advanced zone, where engagements with the enemy are to be expected every moment. The most advanced outposts in front and especially on the flanks, but still more the cavalry patrols on the look-out, ought to be furnished with signal stations communicating with the troops behind. The strolling larger patrols and reconnoitrings ought to be accompanied by "flying" stations in communication with the look-outs in the outpost line. Great advantages may be derived from this precaution. The signal stations in the outposts can, with their telescopes, scan the country before them so carefully, that they can discover any suspicious movement at a distance of several miles, and in a few minutes they can inform the head-quarters of anything of consequence. The dispatched commands, too, can speedily give information about the result of their mission, and last, not least, it contributes greatly to their own safety, that the look-outs may observe them during their march and inform them of any hostile enterprise which may endanger their return, and which may often be visible from the elevated positions

of the look-outs, though hid from the troop concerned ; or by informing the head-quarters of the peril, the look-out can cause assistance to be sent in due time. A brilliant example of this sort is shown from the late war in Afghanistan, where the signal station at Aliboghan, from an invisible distance of many miles, foiled by its information the enterprises of the Momunds. Though Denmark has had no war since visual signalling was adapted for field use, yet from practices in combination with other arms experience has clearly shown their usefulness.

3. During the battle, signal communications between different brigades or larger bodies will often be advantageous, but from the brigadier downwards, only under circumstances when the brigade extends over a greater space of room than usual, or is in want of orderlies. There are not so many data on record regarding this fact that a decisive opinion can be formed. Visual signalling will, during the battle, as in other circumstances, principally be fit for communicating with troops turning the enemy's flank or guarding our own flanks from being turned. A special application, and a very advantageous one, is for communication between artillery and the persons observing the effect of its firing, if it is at any distance. An instructive instance, of this use of signals has been mentioned above from the attack of Fort Fisher.

It cannot be denied that the field telegraph has also been employed on the battle-field several times, and sometimes with great success. Such was the case during the battle of Fredericksburgh, where Franklin's corps had a telegraphic communication with the northern river side during the whole time the battle lasted. The same is told from the war of Paraguay against the allies, where telegraph stations were often worked in the very foremost lines during the action. But this ought scarcely to be recommended on a battle-field, unless the battle is rather stationary, or the side using them has good chances of success ; where the troops are wavering backwards and forwards with the varying chances, or where defeat might be the most probable issue, it will cause too great a loss of *matériel* when so much of it is placed in the foremost lines. This, in fact, was the case in Paraguay, where by-and-bye all the *matériel* fell into the enemy's hands, and its loss was then bitterly felt. It is quite another thing in fortifications or well-fortified positions ; there the telegraph ought to be employed to the utmost extent, and signals chiefly for communicating with points beyond the fortifications.

The rules for signalling that have been pointed out above will, of course, be subject to manifold variations, as the signals or the electric field telegraph becomes more perfected. To employ them in the proper way and at the proper place, it is necessary to be, at any moment, fully aware of their capabilities, as well as of their deficiencies, and a similar knowledge of the two other means of communication—the field telegraph and the orderlies—is indispensable. As both the field telegraph and the signals are from day to day more and more developed and perfected, this knowledge can only be had by those who, during the time of peace, are constantly occupied with

both of these branches of the service. Therefore the best plan would be to unite the field telegraph and signal service in one corps, whose chief during the war or grand manœuvres would be attached to the head-quarters as chief of the whole service of information and communication, and would decide whenever telegraphs, or signals, or orderlies were to be employed. In this way the service was organized towards the end of the late American war, at least in some of the armies, and it proved very satisfactory.

The development which the Danish signalling corps most stands in need of is the acquiring of a greater speed in the transmission of messages. Here is apparently something to be gained by accepting a smaller flag for short ranges as in England; neither is it impossible that a stiff disc, which would always display its whole breadth, might be preferable to the flag. The heliograph will always maintain, where it can be employed, an overwhelming superiority over all other kinds of signalling apparatus. Its chief fault is the necessity for sunshine; this fault is of great importance in our clouded climate; yet, in spite of this, it would even here be a very useful instrument to employ, besides the flags, for when it is nearly impossible to observe the latter in consequence of the hazy quivering of the air on sunny days, the flash of the heliograph will, no doubt, easily penetrate this slight, transparent sort of haze. But if it is to be introduced as the universal apparatus for signalling, it is quite necessary to have an artificial light, sufficiently strong to replace the sun, not only at night, but even on rather clear sunless days. The electric light, of course, would be excellent, and ought to be employed at fixed stations and on board ship, but the machines producing it are not yet sufficiently light and simple for field-use. It may be hoped that they may soon attain a sufficient degree of perfection. In France a simple petroleum lamp is used in connection with a concave mirror, but I have not been able to ascertain whether the light is sufficient for long distances in rather unfavourable circumstances, which appears a little doubtful. In 1879 an electric lamp was employed on board the Danish ironclad "Odin," while signalling with a station on shore. The flashes were given in turning the lamp to and fro, which was a rather slow proceeding, but the light was so intense, that it was scarcely supportable to the eyes when it fell directly on the shore station, which was at a distance of some 4 miles; it was plain that it would have been strong enough for a very long distance.

When the wished-for perfection of the electric light is attained, visual signals probably will be the best means of communication at any distance between 1 mile and 20 miles, messages being sent through the line at a rate of ten words per minute, or even more, in every weather but a pelting rain, a thick snow, or a dense fog. There then remains only one perfection that is to be attained for making visual signalling just as perfect as electric telegraphy. I mean the self-recording of the signals by the receiving apparatus. Nor will this be impossible with the heliograph as a sending apparatus. Suppose the receiving apparatus be a camera obscura, into which light can only penetrate through a rather long and very narrow tube;

then scarcely any light will come into the apparatus, except rays following exactly the direction of the tube. If the tube be directed exactly towards the sending station, any flash from the heliograph there will throw into the camera a sharp ray of light. If it strikes there a slip of paper prepared for the purpose by a chemical process, it will produce a discoloured spot, and if the paper is drawn slowly past the slit, through which the light is penetrating, the dashes and dots of the heliograph will be marked by long and short discolourings of the paper. The only difficulty is the preparing of the paper in such a way that the marks become sufficiently clear and can easily be rendered permanent, so that they are not blotted out on their being subsequently exposed to the light.

There is one complaint that is often brought forward against visual signalling, viz., that the signals run the risk of being intercepted by the enemy; but, in fact, this complaint is most commonly heard from those who have never tried signalling themselves. He who has experienced the difficulty of finding a neighbouring station of whose whereabouts we are not distinctly aware, knows that even a flag station is not so very easy to discover at some distance. Moreover, those messages, the interception of which might cause any harm, are nearly always sent *to the front* from more remote points in the rear, and messages of importance may be partly enciphered. The best use of the cryptograph is to encipher only so much of a message that it is incomprehensible, then there will in no case be a sufficient number of ciphers to enable the enemy's deciphering the message. With the heliograph an interception of the message by the enemy is nearly impossible, as he is obliged to stand exactly in the very narrow cone of light projected from the instrument if he is to see any signal. It is an interesting fact that during the American war no serious mischief was caused by the interception of signalled messages, while, as for telegraphic ones, many were intercepted, causing great trouble and disorder. Thus the famous raids of Morgan were made possible chiefly by an able telegrapher in his train, who intercepted the orders for troops sent on the pursuit, and in replacing them by false ones, foiled repeatedly the attempts at closing with Morgan's excursive party.