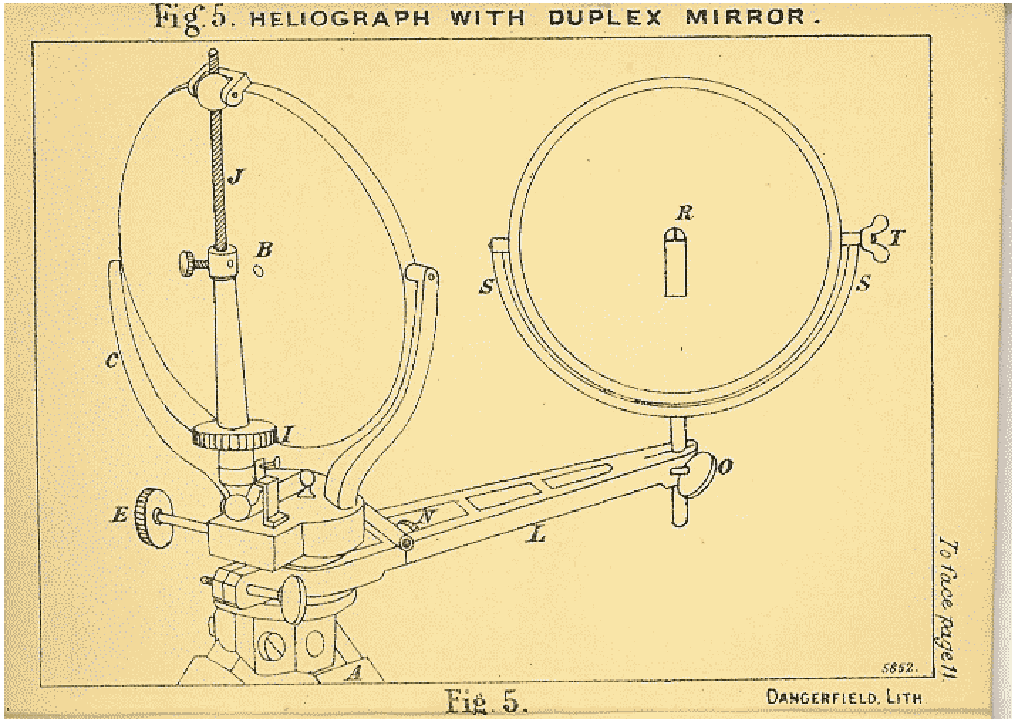
Flashes of brilliance, the Heliograph in Queensland.

A **Heliograph** (Greek :Ἥλιος *helios*, meaning "sun", and γραφειν *graphein*, meaning "write") is a wireless solar telegraph that signals using Morse code flashes of sunlight reflected by a mirror. The flashes are produced by momentarily pivoting the mirror, or by interrupting the beam with a shutter. The heliograph was a simple but highly effective instrument for instantaneous optical communication over 50 km or more in the late 19th and early 20th century. Its major uses were military, survey and forest protection work. Heliographs were standard issue in the British and Australian armies until the 1960s, and were used by the Pakistani army as late as 1975.

There were many heliograph types, though most heliographs were variants of the British Army Mance Mark V version which used a mirror with a small sighting hole in the middle. The sender looked through this hole to align the tip of a sighting rod with the target. He then aligned the mirror so the small shadow that was the reflection of the sighting hole was on the tip of the sighting rod. This indicated that the sunbeam was pointing at the target. The flashes were produced by a keying mechanism that tilted the mirror up a few degrees at the push of a lever at the back of the instrument. If the sun was in front of the sender, its rays were reflected directly from this mirror to the receiving station. If the sun was behind the sender, the sighting rod was replaced by a second mirror, to capture the sunlight from the main mirror and reflect it to the receiving station.



From the *Manual Of Instruction In Army Signalling*, dated 1886

The heliograph had some powerful advantages. It allowed long distance communication without a fixed infrastructure, though it could also be linked to make a fixed network extending over hundreds of miles, as in the fort-to-fort network used in the Geronimo campaign in the US. It was highly portable, required no power source, and was relatively secure since it was invisible to those not near the axis of operation. However, anyone in the beam could intercept signals without being detected. In the Anglo-Boer

War of 1899-1902 where both sides used heliographs, tubes were sometimes used to decrease the dispersion of the beam.

The first recorded use of the heliograph was in 405 BC when the Ancient Greeks used polished shields to signal in battle. In about 35 AD, the Roman emperor Tiberius by then very unpopular leader ruled his vast empire from a villa on the Isle of Capri. It is thought that he sent coded orders daily by heliograph to the mainland, eight miles away.

Sir Henry Christopher Mance (1840–1926), of British Army Signal Corps, developed the first apparatus while stationed at Karachi in Bombay. Mance was familiar with heliotropes through their use in the Great India Survey. The Heliotrope is an instrument that uses a mirror reflect sunlight over great distances to mark the positions of participants in a land survey. The Mance designed Heliograph was easily operated by one man, and since it weighed about seven pounds, the operator could readily carry the device and its tripod. The simple and effective instrument that Mance invented was to be an important part of military communications for many years and although limited to use in sunlight, the heliograph was the most powerful visual signalling device known at that time. In pre-radio days it was often the only means of communication that could span ranges of up to 100 miles with a lightweight portable instrument.

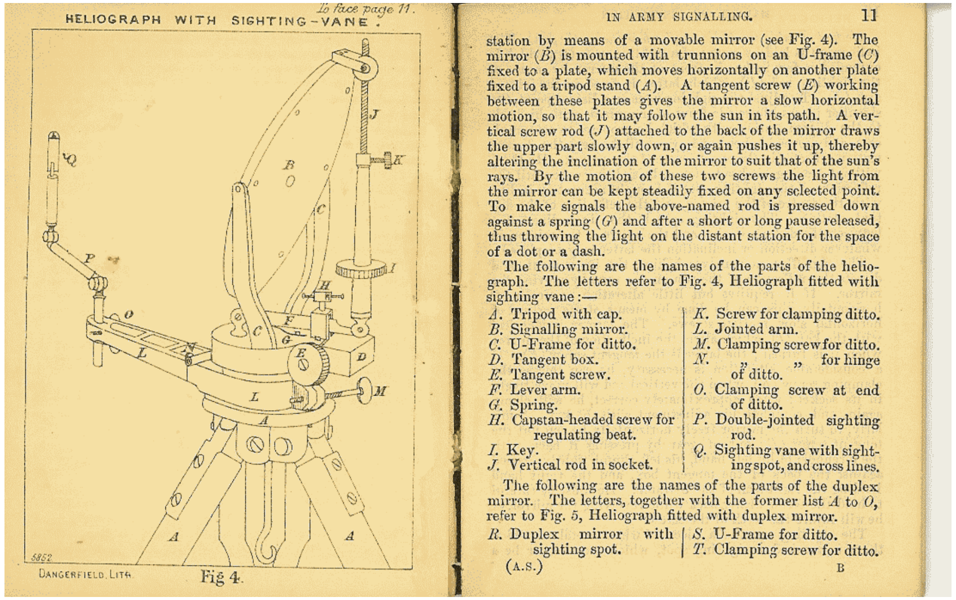
The Brisbane Courier first reported on the use of the Heliograph on the 14th February 1876 reporting on the efforts of Henry Mance in such tones describing the instrument and its potential applications, and its worth quoting in full:

This he (Henry Mance) *has succeeded in effecting by means of simple apparatus, which is known as the Mance Heliograph, or sun-telegraph, the construction of which we have lately had an opportunity of examining at the chambers of Mr. S. Goode, 5, Gray's-in; Square, that gentleman representing Mr Mance in this country. The heliograph consists in the first place of a light tripod stand about four feet long when folded up for transport. On this tripod is screwed a circular mirror, varying in diameter according to the purpose for which the instrument is designed that is whether for field or fixed observations. If for the former purpose the mirror is about 4 inches in diameter while if for the latter it is about 9 inches. The mirror is hung in a frame so as to revolve about a horizontal axis, and it is adjusted to the required angle of incidence with the sun by means of a telescopic connecting rod having a screw adjustment, the top end being attached to the upper edge of the mirror at the back. The horizontal circular traverse of the instrument is obtained by means of a tangent screw gearing into a small horizontal worm-wheel with the centre of which the mirror is connected. By means of the tangent screw and the vertical screwed rod the rays of the sun can be made to fall upon any given point with the utmost precision. The vertical rod behind the mirror is pivoted at the bottom to a lever, the fulcrum of which is on the horizontal worm-wheel, the lever constantly pressing against the lower end of the rod by means of a spring which is placed under it. It will thus be seen that when the rod is depressed it will depress the top edge of the mirror, and draw it slightly backwards, the bottom edge being at the same time slightly raised and thrown forwards. In adjusting the instrument to commence signalling the rays are directed to a point slightly below the distant observer's level, but upon depressing the connecting 1 rod-for which purpose there is a small finger-piece attached to it the flash is raised to the level of the observer, and he sees it. If how the length of these flashes be varied* *and grouped, they can be made to represent letters, and so words composing messages can be spelt out. This is precisely what Mr Mance has done, and by adopting the Morse system of dashes and dots he is able on a fine day to make himself understood by an observer many miles off as easily as one telegraphic operator makes himself intelligible to another. In adjusting the instrument for use a light wooden rod having two brass sliding sights upon it is employed. This is set up in the ground in front of the instrument, and the operator looks through a small space in the centre of .the mirror, from which the quicksilver has been removed, toward the station with which he desires to communicate. The upper sight on the rod is then moved vertically until the centre of the mirror, the sight, and the distant station are truly aligned. Hence when the mirror is directed on to the sight it is in true line pith the distant station, and can be seen by the observer there. This will, of course, be whenever the angle of the mirror is raised when depressed, or in its normal position, the flash rests upon a cross piece on the rod, and, according as the sun's horizontal and vertical motions cause the flash to deviate from the true line, the signaller is able to see and to correct the error by means of the adjustments on the instrument. The observer at the distant station having seen the bright star-like appearances sets his instrument to the point at which they appear and acknowledges the fact, and the parties being thus placed in communication, the interchange of messages proceeds upon the system we have mentioned-namely, the Morse alphabet.*

The applications of the heliograph to civil purposes are not less numerous than those to military use. It would serve as a substitute for wires in countries where the electric telegraph would not pay, and where bunk lines existed they could be fed by the heliograph, which would effect communication with the outlying district. It could be used for temporary purposes on special occasions inland, while there are countries on the coasts of which it might be substituted for expensive submarine cables. In the event, too, of short sub- marine cables failing, as they often do, it could be used for maintaining communication, provided the weather permitted. In short the heliograph would appear to be an admirable adjunct to the electric telegraph in all countries, while in some it would supersede it with advantage. It is, as we have previously observed, already in use in India, and we are informed that our own Government as well as several foreign Powers are investigating its merits with a view to its adoption.

In a country the width and breadth of Australia largely without the infrastructure of fixed telegraph, the concept of a portable means of communication over long distances had obvious appeal and the use of Heliographs continued to attract media attention, the *Brisbane Courier* also reported on its use in South Africa during the Zulu War of 1879 and reported retrospectively on its use during the Jowaki-Afridi Expedition of 1877-78 which allowed the British to test the Heliographs under wartime conditions.

Two columns operating in the Afridi hills were supplied with volunteer signallers, Major Noel Money, of the 3rd Sikhs acting with General Keyes, and Captain Wynne of the 51st Light Infantry with General Ross. So strongly did the units involved report on the Heliographs positive use that on the organisation of the Afghan expedition in 1880 heliographs were ordered to be supplied to each division.



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station by means of a movable mirror (see Fig. 4). The mirror (*B*) is mounted with trunnions on an U-frame (*C*) fixed to a plate, which moves horizontally on another plate fixed to a tripod stand (*A*). A tangent screw (*E*) working between these plates gives the mirror a slow horizontal motion, so that it may follow the sun in its path. A vertical screw rod (*J*) attached to the back of the mirror draws the upper part slowly down, or again pushes it up, thereby altering the inclination of the mirror to suit that of the sun's rays. By the motion of these two screws the light from the mirror can be kept steadily fixed on any selected point. To make signals the above-named rod is pressed down against a spring (*G*) and after a short or long pause released, thus throwing the light on the distant station for the space of a dot or a dash.

The following are the names of the parts of the heliograph. The letters refer to Fig. 4, Heliograph fitted with sighting vane :—

A. Tripod with cap.	*K.* Screw for clamping ditto.
B. Signalling mirror.	*L.* Jointed arm.
C. U-Frame for ditto.	*M.* Clamping screw for ditto.
D. Tangent box.	*N.* „ „ for hinge of ditto.
E. Tangent screw.	*O.* Clamping screw at end of ditto.
F. Lever arm.	*P.* Double-jointed sighting rod.
G. Spring.	*Q.* Sighting vane with sighting spot, and cross lines.
H. Capstan-headed screw for regulating beat.	
I. Key.	
J. Vertical rod in socket.	

The following are the names of the parts of the duplex mirror. The letters, together with the former list *A* to *O*, refer to Fig. 5, Heliograph fitted with duplex mirror.

R. Duplex mirror with sighting spot.	*S.* U-Frame for ditto.
	T. Clamping screw for ditto.

(A.S.) B

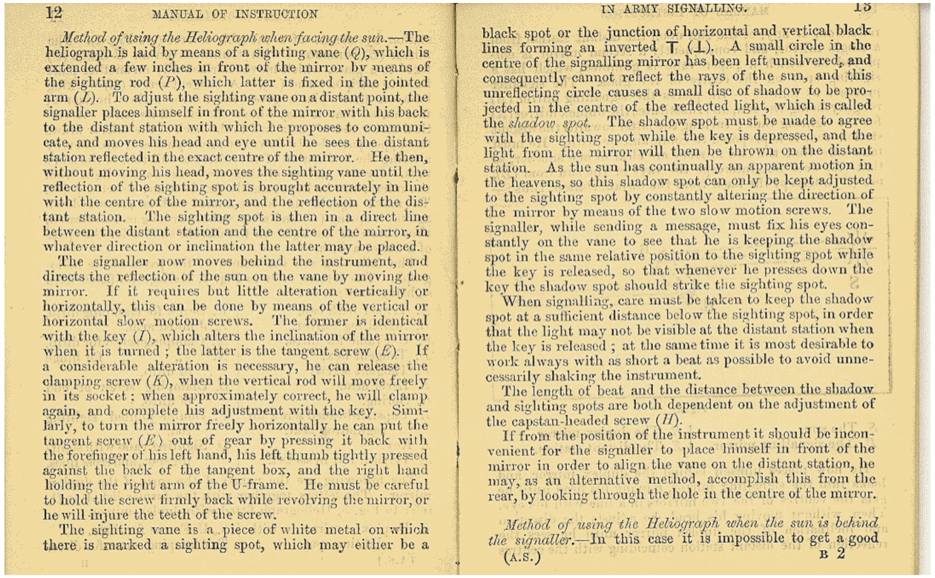
From the *Manual Of Instruction In Army Signalling*, dated 1886

Spain conducted experiments with the Heliograph at this time owing to difficulties experienced in maintaining electric cables across the Straits of Gibraltar and a series of experiments was conducted by which Madrid was placed in communication with Ceuta and Algeciras by optical telegraphy. Orders were issued on the completion of these experiments for the permanent establishment of heliographic communication between Tangier, Tarifa, Ceuta, and Algeciras.

The NSW Government were not slow to catch on either, conducting a series of experiments in July 1879 and on a clear day successfully sent messages from Woodford in the Blue Mountains to Woollahra, a distance of fifty miles. The operators were acting Sergeant-Major McGregor of the NSW Permanent Staff, and Sergeant Corbett of the Torpedo and Signalling Corps.

On the 11th of October 1880, the Queensland Volunteer Force conducted its first experiment in the use of the Heliograph, and arranged on this day between 11.00 am and 1.00 pm that a message would be sent from Fort Lytton at the mouth of the Brisbane river to One Tree Hill as Mt Cootha was then known. A Mr Gregory was in charge of the Heliograph placed on One Tree Hill, Corporal Sharp of the Engineers the instrument at Fort Lytton. Corporal Sharp had taken a personal interest in signalling by Heliograph and improving the knowledge of its use within the QDF. Within a short period of commencing the experiment, he had taken the bearings of One Tree Hill and flashed the mirror about it with a wide range to pick up tho other party. The Brisbane Courier reported *'Suddenly a bright star gleamed from the distant hill, showing that our flash had been seen, and then communication was easily kept up'.* The Heliographs used for this experiment had been made locally in Brisbane and while their description is unknown, we can be reasonably satisfied that they confirmed to common construction.

From this time on the Heliograph continued in use from Fort Lytton. In 1881 units strengths were telegraphed to the city via a signal flag relay station on Hemmant Hill. The Fort Lytton signallers were also at work with another Heliograph party based at *Eldernell*, the Colonial Secretary's residence on a hill near Breakfast Creek.



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Method of using the Heliograph when facing the sun.—The heliograph is laid by means of a sighting vane (*Q*), which is extended a few inches in front of the mirror by means of the sighting rod (*P*), which latter is fixed in the jointed arm (*L*). To adjust the sighting vane on a distant point, the signaller places himself in front of the mirror with his back to the distant station with which he proposes to communicate, and moves his head and eye until he sees the distant station reflected in the exact centre of the mirror. He then, without moving his head, moves the sighting vane until the reflection of the sighting spot is brought accurately in line with the centre of the mirror, and the reflection of the distant station. The sighting spot is then in a direct line between the distant station and the centre of the mirror, in whatever direction or inclination the latter may be placed.

The signaller now moves behind the instrument, and directs the reflection of the sun on the vane by moving the mirror. If it requires but little alteration vertically or horizontally, this can be done by means of the vertical or horizontal slow motion screws. The former is identical with the key (*I*), which alters the inclination of the mirror when it is turned; the latter is the tangent screw (*E*). If a considerable alteration is necessary, he can release the clamping screw (*K*), when the vertical rod will move freely in its socket; when approximately correct, he will clamp again, and complete his adjustment with the key. Similarly, to turn the mirror freely horizontally he can put the tangent screw (*E*) out of gear by pressing it back with the forefinger of his left hand, his left thumb tightly pressed against the back of the tangent box, and the right hand holding the right arm of the U-frame. He must be careful to hold the screw firmly back while revolving the mirror, or he will injure the teeth of the screw.

The sighting vane is a piece of white metal on which there is marked a sighting spot, which may either be a

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black spot or the junction of horizontal and vertical black lines forming an inverted T (⊥). A small circle in the centre of the signalling mirror has been left unsilvered, and consequently cannot reflect the rays of the sun, and this unreflecting circle causes a small disc of shadow to be projected in the centre of the reflected light, which is called the *shadow spot*. The shadow spot must be made to agree with the sighting spot while the key is depressed, and the light from the mirror will then be thrown on the distant station. As the sun has continually an apparent motion in the heavens, so this shadow spot can only be kept adjusted to the sighting spot by constantly altering the direction of the mirror by means of the two slow motion screws. The signaller, while sending a message, must fix his eyes constantly on the vane to see that he is keeping the shadow spot in the same relative position to the sighting spot while the key is released, so that whenever he presses down the key the shadow spot should strike the sighting spot.

When signalling, care must be taken to keep the shadow spot at a sufficient distance below the sighting spot, in order that the light may not be visible at the distant station when the key is released; at the same time it is most desirable to work always with as short a beat as possible to avoid unnecessarily shaking the instrument.

The length of beat and the distance between the shadow and sighting spots are both dependent on the adjustment of the capstan-headed screw (*H*).

If from the position of the instrument it should be inconvenient for the signaller to place himself in front of the mirror in order to align the vane on the distant station, he may, as an alternative method, accomplish this from the rear, by looking through the hole in the centre of the mirror.

Method of using the Heliograph when the sun is behind the signaller.—In this case it is impossible to get a good

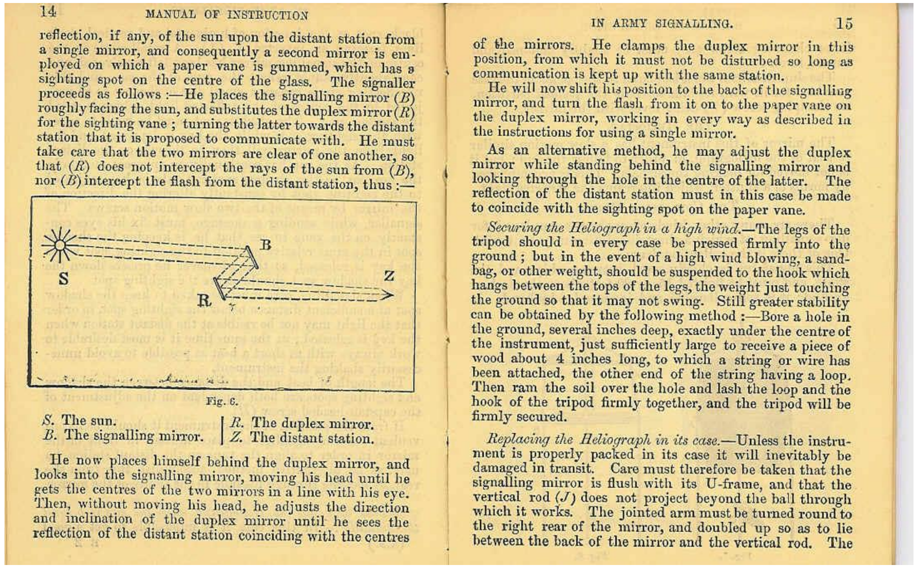
(A.S.) B 2

From the *Manual Of Instruction In Army Signalling* dated 1886

The first message to *Eldernell* was despatched at 11.00 am by Colonel Blaxland: " *Numbers in camp: Staff 11; Field Batteries 106 ; Ordnance Corps, 74; 1st Regiment, 183; 2nd Regiment, 122 ; Brisbane Cadets, 71; Toowoomba Cadets 27 total, 594. Rain last night, fine now. Try 64-pounder this afternoon. I have commenced bridge. Drill progressing steadily."* The Colonial Secretary replied with a certain Palmerian brusquenest *"Message received, glad to hear going on all right. Very much disappointed, expected a larger number*". The operators at *Eldernell* were Mr Starke and Sapper Sharp, while Lieutenant Thomas of the Torpedo Corps operated the Heliograph at Lytton. Experiments were also conducted that year in the encampment in the use of signal lamps at night.

The shortcomings of the Heliograph however were apparent during shell practice at Sandgate by the No1 Battery, Qld Volunteer Artillery in February 1883 when the day was too cloudy to permit the use of the Heliograph. Two targets had been moored in the Bay in the direction of the mouth of the Pine River at 1,200 and 2,000 yards distance respectively from the end of the Brighton Beach Flat under the cliff where it was intended that the guns should take up their position. It was found necessary though to move the guns a considerable distance further along the beach in order to keep the line of fire as far as possible from the direction of the Brighton Hotel and so the ranges of the targets were reduced by several hundred yards. Proceedings were commenced by opening fire on a target which consisted of a quarter-cask surmounted by a red flag. A party of Engineers had accompanied the Battery as signallers and took up their position on the beach opposite the targets at right angles with the line of fire. The effect of each shot was signalled to the battery by means of flags due to the cloud cover.

In June 1883, the *Mackay Standard* reported a recent expedition to Mount Dalrymple by Mr Henry, Harold Finch-Hatton and C C Rawson and T P Porter. Mt Dalrymple reaches a height of 4,300 feet above the sea level. The purpose of the expedition was partly scientific and one of the most interesting features of their trip was the use of the Heliograph from the mountains summit, its signals distinctly visible in Mackay, The Hollow, Jolimount, and St Helens Island a distance of more than fifty miles from Mackay.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reflection, if any, of the sun upon the distant station from a single mirror, and consequently a second mirror is employed on which a paper vane is gummed, which has a sighting spot on the centre of the glass. The signaller proceeds as follows :—He places the signalling mirror (*B*) roughly facing the sun, and substitutes the duplex mirror (*R*) for the sighting vane ; turning the latter towards the distant station that it is proposed to communicate with. He must take care that the two mirrors are clear of one another, so that (*R*) does not intercept the rays of the sun from (*B*), nor (*B*) intercept the flash from the distant station, thus :—

Fig. 6.

S. The sun. | *R.* The duplex mirror.
B. The signalling mirror. | *Z.* The distant station.

He now places himself behind the duplex mirror, and looks into the signalling mirror, moving his head until he gets the centres of the two mirrors in a line with his eye. Then, without moving his head, he adjusts the direction and inclination of the duplex mirror until he sees the reflection of the distant station coinciding with the centres

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of the mirrors. He clamps the duplex mirror in this position, from which it must not be disturbed so long as communication is kept up with the same station.

He will now shift his position to the back of the signalling mirror, and turn the flash from it on to the paper vane on the duplex mirror, working in every way as described in the instructions for using a single mirror.

As an alternative method, he may adjust the duplex mirror while standing behind the signalling mirror and looking through the hole in the centre of the latter. The reflection of the distant station must in this case be made to coincide with the sighting spot on the paper vane.

Securing the Heliograph in a high wind.—The legs of the tripod should in every case be pressed firmly into the ground ; but in the event of a high wind blowing, a sand-bag, or other weight, should be suspended to the hook which hangs between the tops of the legs, the weight just touching the ground so that it may not swing. Still greater stability can be obtained by the following method :—Bore a hole in the ground, several inches deep, exactly under the centre of the instrument, just sufficiently large to receive a piece of wood about 4 inches long, to which a string or wire has been attached, the other end of the string having a loop. Then ram the soil over the hole and lash the loop and the hook of the tripod firmly together, and the tripod will be firmly secured.

Replacing the Heliograph in its case.—Unless the instrument is properly packed in its case it will inevitably be damaged in transit. Care must therefore be taken that the signalling mirror is flush with its U-frame, and that the vertical rod (*J*) does not project beyond the ball through which it works. The jointed arm must be turned round to the right rear of the mirror, and doubled up so as to lie between the back of the mirror and the vertical rod. The

From the *Manual Of Instruction In Army Signalling* dated 1886

Recruits invited to enlist in the Brisbane Engineers in February 1885 were to be a minimum height of five feet, six inches tall and that Mechanics and men *desirous of self improvement and to become more skilled in their various crafts* were required. Practical training was offered Military Engineering including Bridging and Field Work, Submarine Mining including Electricity, Field Surveying and Telegraphy and Signalling by Heliograph and the Lime Light the level of skill now developed within the QDF in these apparatus now provided sufficient skill to train others. Training was conducted twice weekly on Tuesdays and Thursdays in the Adelaide Street Drill Shed between the hours of 8.00 pm & 9.00 pm.

The annual Easter Encampment of the Qld Defence Force in 1885 were again supported by the Heliograph and were manned by now Sergeant-Major Sharpe of the Brisbane Engineers and assisted by Corporal Barry, these two based within the Fort, a second Heliograph based on Reformatory Hill manned by Quartermaster-Sergeant O'Brien and assisted by Sapper Zlyncki. The encampment included a simulated attack by the *Gayundah* and a land based attack by various units. Lieutenant-Colonel Drury commanding units based within the fort requested the heliograph signal *"The Lytton Fort to commence firing"* and a second after the message was flashed the first gun from the fort opened fire. During the engagement heliograph communication was maintained between the fort and the Reformatory Hill station and at the conclusion of the exercise two mines were exploded as the *Gayundah* was nearing the fort throwing up a column of water about 200 ft into the air.

During the Infantry Officers Instruction Class conducted at Brisbanes Victoria Barracks in October 1889, Major Des Voux lectured on ‘Outposts’ while "The Defence of a Position" formed the subject delivered by Major Druitt of the Royal Engineers. Subjects such as topography, knotting, and lashing received as much attention as the limited time permitted while it was noted that a number of subjects which usually form part of a soldier's training such as musketry, signalling with flags, the heliograph, instruction in shelter trench exercise, military law were entirely neglected.

The Heliograph was never far from the news, though the growth in its use was not widespread. A sternly worded letter to the editor of the *Brisbane Courier* on the 12th of February 1895 suggesting heliograph stations be based at Caloundra and Moreton Island and a telegraph link between Landsborough and Caloundra as a result of scares including a boatload of escaped convicts from New Caledonia and overdue shipping being capable of being reported swiftly had these means been available.

A few short years later, Queenslanders were still lamenting a fall off in priorities given to signalling, on the 6th of June 1900 a Mr E W Pechey of Crow's Nest, wrote to the Editor of the *Brisbane Courier* lamenting *"We have in Toowoomba many young men enrolling themselves in an artillery force. Could we not do something more? We will suppose a British gunboat away off Cape Moreton wishing to signal. She can send out any number of signals, yet who is there to receive them ? Can we not organise a heliograph department? We are very well placed to carry this out. Have we any operative stations on the coast to take these signals ? There are many good men in Queensland now who could be formed into a good heliograph corps, and the various trigonometrical points could be used by a properly-organised engineer corps.*

In August 1903, a lecture was given by Lieutenant H F Wilkins of the Submarine Miners at the United Services Institute to approximately thirty Sergeants of the Queensland Defence Force on army signalling. The lecturer dealt with his subject from the commencement of signalling in the olden times of the beacon fires and brought his audience through every system of signalling to the then recent Anglo-Boer War in South Africa. Lieutenant Wilkins was an early character of Queensland and noted that Queensland military signalling appeared behind the times as both training and priorities in heliographs and methods of signalling by night were conspicuous by their absence and although a field telegraph wagon was in existence somewhere about Brisbane, it had not yet made its appearance in public. Lieutenant Wilkins created two electric Morse stations in the room with a full complement of Instruments such as the Morse key, sound reader and carrier. The lecturer impressed upon his audience the necessity of every sergeant, particularly those of the Mounted Infantry being conversant in the Morse signals and stated that any ordinary student of Morse with half-an hour's practice each day for about three months could make himself proficient to read and send any flag signals. At the conclusion of the lecture Quartermaster-Sergeant Ede moved a vote of thanks to the lecturer which was given with acclamation.

By November 1903, the first experiments in use of the Heliograph at night were conducted, using the light of a full moon messages were successfully sent a distance of ten miles using a Heliograph with a five inch mirror. Mr V V Chambers of Heidelberg in Melbourne had read with interest the Queensland experience of the Heliograph and having transmitted signals himself by sunlight a distance of thirty miles, he was tempted to repeat the experiment at night and successfully transmitted messages from Heidelberg to Nyora, a distance of ten miles and observers in Nyora reported the signals at times 'splendidly bright'.

From here, the use of the Heliograph having been given every priority during the Anglo Boer War, and its use widely reported is overtaken by progress and the use of electric telegraphy. Though circumstances would always dictate the Heliograph held a place within signalling for many years to come electric means were first and foremost now regarded as the most reliable means of message transmission though the heliograph was not to fade from military use for another 60 years.

Suggested reading:

National Library of Australia: http://trove.nla.gov.au/

Manual of Army Signalling – 1886

The Titi Tudorancea Bulletin:
http://www.tititudorancea.com/z/heliograph.htm