

FIRING THE GUNS - 2

Watkin Depression Position Finders

David Moore

Having visited many of our remaining Victorian coast defence forts and batteries I was fascinated by the now empty position finding cells that litter them. My researches into the instruments that were sited within these enigmatic chambers has led me along many blind alleys. It seems that no one has published a definitive history of the subject. Whilst I do not presume to claim that I know all there is to know about the different types of range and position finder in use during the late Victorian period I can at least state that I have gone some way to unravelling the problem. The difference between a Depression Position Finder and a Depression Range Finder and that between an Electric Position Finder and a Horizontal Position Finder may be more difficult than I have so far determined. To add to the confusion original documents also label some instruments as Depression Horizontal Receivers, and Horizontal Transmitters or just plain Position Finders. If anyone can provide any more information I will be happy to publish it. Meanwhile I have attempted to unravel some of the mysteries and may have got it wrong in the process. Here goes.

The main instruments used to calculate range and position in coast batteries during the later Victorian period were the range finder and the position finder. The range finder in use was known as the Depression Range Finder or. D.R.F. whilst the position finder came in two varieties, the Depression Position Finder, D.P.F. and the Horizontal Position Finder or H.P.F. To further complicate matters there were different types of horizontal position finder depending on the length of the base, viz the 'Short Base Observation Station Position Finder' or S.B.P.F. (Two of these were fitted to Fort Gilkicker in the 1890s These will be described in the next article). Presumably there was a corresponding long

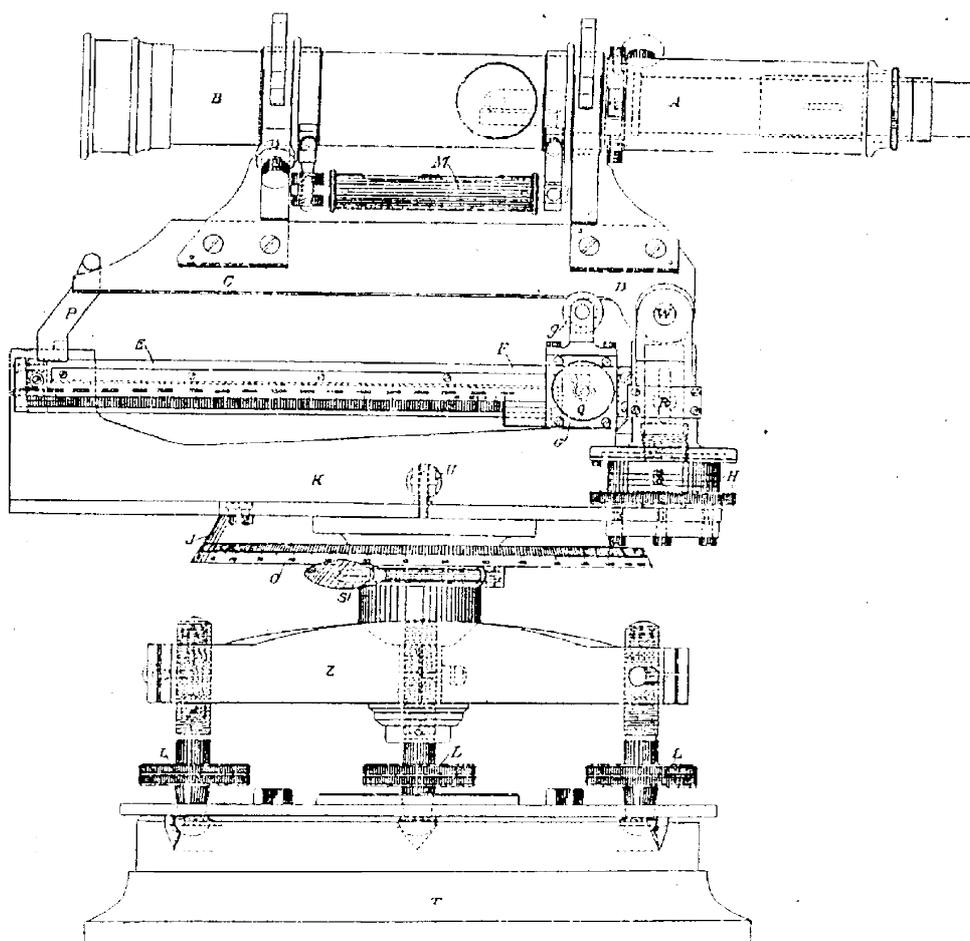
base horizontal position finder, but I have not yet come across references to it. The late Victorian instruments were designated by letter and mark. i.e. *D Mark I* More of this in the next article when I shall attempt to explain how the instruments worked in more detail.

The invention and development of these complicated range and position finders can be attributed to one man, a Major Watkin. Consequently they were often known as Watkin Range or Position Finders.

At first I assumed that the two types of finder differed in that the range finders could calculate only range whilst the position finders were able to calculate range and position. But I have since come to the conclusion that depression range finders were also capable of determining position. They differed only in the way that they did it. The 1915 manual of Coast Defence Range Finding explains that the range finder was able to determine the distance and training of the target from itself whilst the position finder could determine the distance and direction to the target and in addition the position of the object could be plotted by the instrument on a correctly oriented chart so that range and training from any other site marked on the chart could therefore be planned. The position finders had a chart table beneath the sighting telescope and this was mounted on three pillars, often of concrete, in a position finding cell.

The first range finders

The first Watkin range finders were fitted to tripods. The Officer Commanding Royal Artillery Sheerness 2/10/86 pointed out that it would be desirable to mount the Watkin depression range finder in a permanent position instead of on its tripod. On 18/10/86 Major Watkin concurred. The Director of Artil-



Rangefinder
Depression
Mark II*

lery 6/12/86 directed the Officer Commanding Royal Artillery to forward the instrument to Major Watkin in order that a suitable fitting could be made. The instrument was forwarded and required a slight alteration which was carried out.

At the suggestion of Officer Commanding Royal Artillery Isle of Wight, the Director of Artillery 31/03/87 requested the Officer Commanding Royal Engineers to erect concrete pillars for depression range finders. Major Watkin 25/3/87 proposed the dimensions. The Officer Commanding Royal Artillery and Officer Commanding Royal Engineers Isle of Wight 29/4/87 considered the proposed dimensions too slight. The Commanding Engineer suggested that the pillars be embedded in the face of the parapets. The cost for 10 be about £12 10s which were to come into the Royal Engineer incidental expenses.

D.R.F. emplacements

The emplacement for the depression range finder consisted of a pit 6 feet in diameter in which was built a concrete or brick pillar, 4 feet 4 inches high, 1 foot across and projecting two feet from the side of the pit. On the top of this pillar was fixed a small brass stand to take the levelling screws of the instrument. The ranges were transmitted to the gun electrically. One or more datum points were required for the D.R.F. as well as for the position finder. This was to allow the instrument to be adjusted for height above the water level. The datum could be the end of a pier, a rock, or any similar object always surrounded by water, although by 1914 special floating buoys were often used. The best distance was regarded as about a mile off to give a long base but still be seen easily. Where the tide is small one datum point visible from each instrument was sufficient to check it

but if the rise of the tide was considerable each instrument needed to see two datum points, one on each flank, to allow the instrument to be set during action if necessary. From this I assume that the D.R.F. read the state of the tide by directing the telescope of the instrument on the water level surrounding a known datum point rather than it being adjusted using tide tables.

D.R.F.s issued

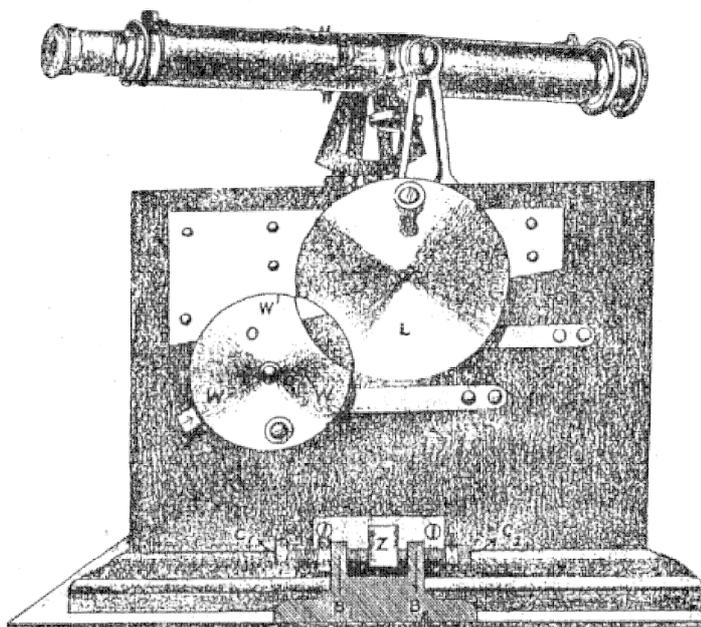
By the late 1890s depression range finders had been issued in great numbers. They were supplied to batteries where there was a height of at least 25 feet in their immediate neighbourhood. The D.R.F. could take the place of the position finder, should it be put out of action or get out of order. In choosing sites for it alternative positions were selected on both flanks of the battery so as to avoid the effect of smoke. A fair field of view was necessary with as much security as possible. By 1899 the following types of depression range finders were fitted to many coast batteries -

	for batteries
Mark I	85 to 190 feet
Mark I A	60 to 110 feet
Mark I B	110 to 240 feet
Mark I C	240 to 590 feet
Mark I D*	30 to 60 feet
Special	at other heights

*This instrument has a screw and drum arrangement different from that of other marks. Specials were issued to Coalhouse Fort and Needles Battery.

Position Finders

Major Watkin had first proposed the depression position finder for elevated batteries in October 1879 to take place the place of the Position Finder which

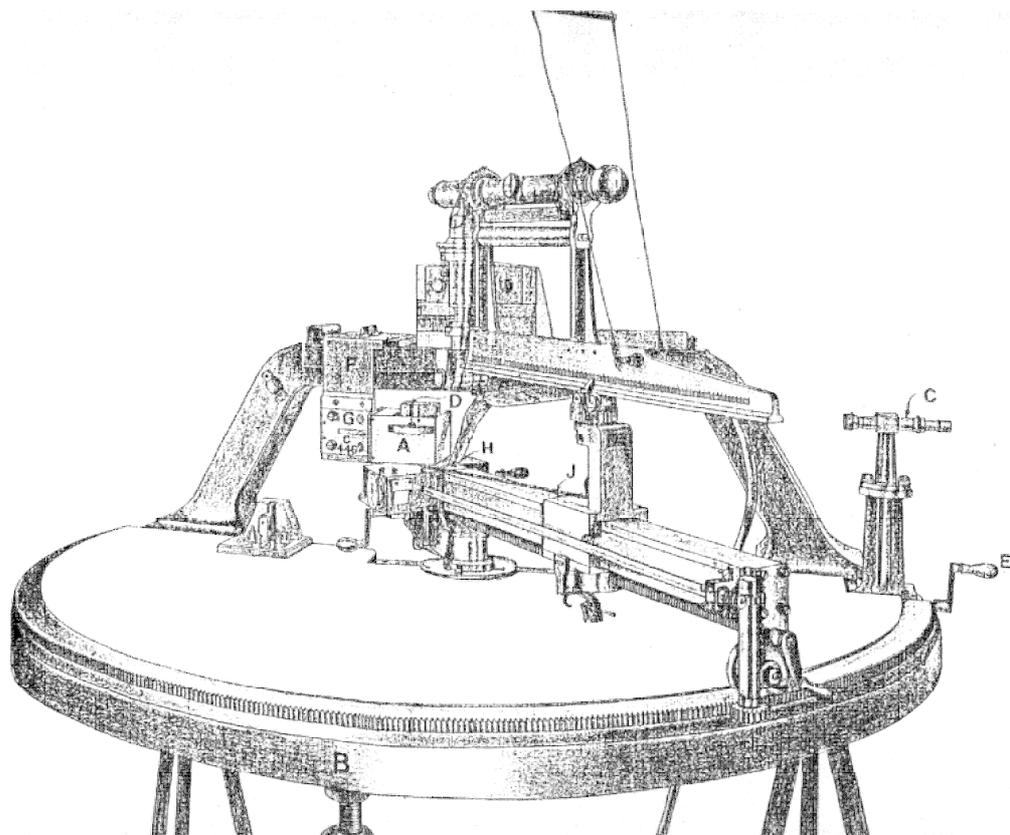


Horizontal Position Finder Transmitter Mark II (for instructional purposes)

had been tried by the Range Finding Committee at Fort Picklecombe in January of that year. The details of the instrument were kept secret, for fear of its benefits falling into the hands of the enemy which it was intended to help guard against. There were two natures of position finder: the 'Depression' and the 'Horizontal'. The depression position finder was based on the earlier depression range finder and in some cases the terminology can become confused. The horizontal position finder was later referred to as the Electric Position finder in some official documents, presumably because it transmitted its data to the guns electrically.

Using the Depression Position Finder

With the depression position finder, the telescope was pivoted vertically and horizontally, so that it could be directed on to the water anywhere within the field of view from the cell. A simple but ingenious electrical device, the 'horizontal attachment', allowed the directing of this instrument onto the waterline of any floating object to indicate on a couple of dials placed inside a recess close to the gun, the range and training to be given to the gun, which would result in the target being hit by the projectile fired at that instant.



Position
Finder G

A similar result could be obtained with the receiving instrument of the horizontal position finder, where two observations were combined, if both instruments were directed upon the same part of the ship. By merely observing the ship the gun could be directed upon it.

Determining the range and position

In the case of a moving ship, the gun needed to strike in advance of it. To determine where to direct the fire of the gun a pencil was attached to receiving instrument or to the depression range finding instrument. This was used to plot the movement of the ship as the telescope was tracked across the chart, or plotting table, following the ship. A prediction could then be made as to the future position of the target at a selected time corresponding to the time of the projectile's flight. The data on the future position of the ship was then relayed electrically to the gun emplacement, where it was displayed on the gun dials. The gun layer would

lay his gun on the spot that the target would occupy in, say, half a minute by the use of graduated scales for line and for elevation. The gun captain then signalled 'ready' to the observer who would fire the gun at the exact moment calculated to bring the shell and ship to the same place at the same time.

Horizontal Position finder

The horizontal position finder used two telescopes. One was sited some distance away from the gun position and acted as a transmitting cell. The other, or receiving cell was sited close to the guns, but not so close that its observer was obstructed by the smoke from the firing of the guns. Both the transmitting cell and receiving cell were visible from each other. The receiving instrument was similar in pattern to the depression instrument, and if it was placed at a significant height above the water, could, with advantage, actually be a depression range finder. The transmitting instrument consisted

The Horizontal Position Finder

The range of the target is calculated by each instrument measuring the angle to the target respective to the base line, which is of known length. The receiving instrument measures angle r . The transmitting instrument measures angle t and sends it to the receiving instrument electrically, to be displayed on a dial, where both angles are used to determine the position and range of the target using a mechanical means. I assume that even in the earlier instruments all of the calculations were performed without the need for the formula to be calculated mentally.

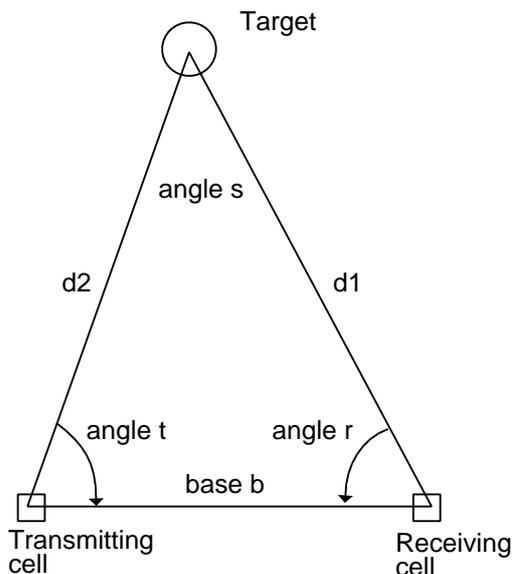
$$s = 180 - (r + t) \quad \text{- angles of a triangle}$$

$$\frac{d1}{\sin t} = \frac{b}{\sin s} \quad \text{- sine rule}$$

$$d1 = b \times \frac{\sin t}{\sin s}$$

In the later instruments both observers merely followed the target with their instruments and the necessary range and direction was automatically relayed to the gun dials.

Using the chart beneath the receiving instrument the course of the target ship is observed and the position that it is likely to be at in the immediate future is



of little more than a telescope and did not need a chart table attached. The distance between the two instruments was known and formed the base of the triangle, the target being at the apex. In certain situations it was advisable to have a depression instrument at the transmitting end as well as at the receiving end, and sometimes a single receiving instrument was combined with two transmitting ones with base lengths in different directions.

The target was observed through the telescopes of both instruments and the bearing of the target from the transmitting instrument was relayed by electrical means to the dials of the receiving instrument. Here both the bearings were known and the range of the target was calculated automati-

cally by the instrument. In later Marks, certainly by the early 1900s it was all done with mirrors! The observers at the transmitter and receiver each following the target, the receiving instrument making necessary adjustments to coordinate the two instruments which were connected electrically.

The difficulty lay in converting this range and direction as found at the observing station, horizontal or depression, instantaneously into corresponding figures for the gun, which may have been some distance off, and the equally instantaneous communication of these figures to the gun detachment for immediate use. Any delay in forwarding the information would clearly result in the guns missing their target.



Watkin prepares for the trial

Between the year 1879 and 1887 the Watkin depression position finder was put to trial at Plymouth. On 30/4/84 The Officer Commanding Royal Artillery Western District requested that instructions be given to have the position finders at forts Bovisand and Picklecombe put in working order by the end of May for the instruction of Royal, Militia and Volunteer Artillery. Major Watkin RA on the 11/05/84 being called upon by Director of Artillery on the 6/5/84 for the report said that Fort Picklecombe was at present fitted with electric position finders but was to be worked by depression system but that the instruments which were on loan from Commissary General were returned to store in 1879. He could not say how long it would take to put the fort in working order. As regards Fort Bovisand he said the observing stations were finished, the wires connecting them with the batteries laid and also those from central station to centre of group. The positions finders were ready but required fixing in position. The range cards were worked out and the training arcs of the guns laid but they required examination to see if they agreed. Shunts and transmitters which had been provided required to be adjusted and set up in position. Electric batteries were required to work the dials and Morse recorders obtained on loan or demand. He could not say how long this would take. On 27/05/84 the Director of Artillery directed Major Watkin to proceed to Plymouth.

The D.P.F. described

The depression position finder consisted of a telescope which was mounted on a pedestal so that the operator could see his target directly through the telescope. The pedestal, and therefore the instrument, was fixed in position at a known height above the waterline. The range of the target was determined by measuring the angle of depression of the target from the instrument, the base of the triangle to be solved being the height of the instrument above the water. The direc-

tion of the target was observed by fixing the telescope above a plane table, the angle of line being read directly as the target moved and was tracked by the observer looking through the telescope.

The whole apparatus worked perfectly when trialled at Plymouth, NCOs working the position finders with eminent success. Lewis writes, It was a pretty sight to watch the shot from a group of four guns fired together curving down towards the target, and striking the water close to it. This basic method of predicting was to remain in use, with minor variations, for the rest of the time that coast artillery was in use, i.e up to 1956.

The principle of the depression range finder was later applied to a gun sight for shorter range weapons. This 'autosight' as it was known, was used by the gun layer to direct his projectile at a ship by following the bow wave of the target with the sight telescope, the gun being given the correct elevation to hit the target automatically. This also remained in service up to 1956.

The 1887 Plymouth trials

One of the trials at Plymouth in 1887 included the successful firing of the guns of the Breakwater Fort using position finders more than a mile away on Staddon Heights. This demonstration proved that placing the position finders some distance away from the guns, while not ideal, did not present insuperable problems. The Instrument used was fixed to a plotting table four feet long and 2 feet 3 inches wide; about the size of a large drawing board. It was placed in a small building or cell partly sunk, in the ground, and having a long low opening in front to allow the observer's telescope to cover the whole of the water in front of the gun it served. The roof of the cell was covered with earth to give it protection and to allow it to blend into the hill on which it was constructed. The cell for the guns at Bovisand, close by, was 250 feet above sea level, whilst that for the Breakwater Fort was 350

feet. Each instrument was to give the range from a single point and therefore served a single gun, unless two or more guns were close enough together that their shot would strike a ship when they all fired in parallel over the same water. This was the case with the guns in Fort Bovisand which were grouped in fours. Those in the Breakwater Fort were worked singly as they had widely divergent arcs of fire. By this time it was common for single guns to form a 'group'.

Plymouth instruments

The instruments at Plymouth were able to read a maximum range of about 5,000 yards. The latest service pattern was capable of reading ranges of 7,000, 12,000 and 14,000 yards from the instrument, the arc of fire of the guns falling within this range. The smaller service pattern used was sufficient for the older M.L. guns which were then mounted. The cell to accommodate them was 9ft. long by 8ft. 6-inches wide in internal dimensions.

The cells for the larger pattern instruments were a little bigger allowing two observers, which was always convenient and sometimes necessary. The top of the roof was three feet above the axis of the telescope of the instrument. The maximum arc of view was 180 degrees. As much light as possible was admitted. The cells should be 50ft. apart but circumstances such as those at Plymouth, made it necessary for them to be closer, even touching.

A row of five cells was constructed side by side on Staddon Heights, stepped down the hill, with a communicating passage to the rear.

Siting the instruments

Finders using the depression system were to be sited as high as possible, up to 800ft. which was considered high enough. A site as low 25ft would give good enough results for ranges of up to 2,000 yards if close enough to the guns. In a horizontal system the effective base, the perpendicular distance from one end of the base to the opposite side

of the triangle, for a range of 10,000 yards, was not to be below 1,200 yards. the receiving cells were to be placed within 500 yards from their groups of guns. Several cells together formed a station.

The gun battery

In the gun battery the fittings associated with the position finders are the electric batteries, which could be sited almost anywhere handy; the firing plug, about 6 inches square, which took the end of the flexible insulated wires leading to the electric tube for firing the gun, and which must be near to the gun; and the dials and firing key. The key is best sited in a recess 2 feet 3 inches long by 1 foot 4 inches wide by 8 inches deep, and needed to be placed so that a man could read the dials and give the word of command to the gun at the same time. In 1887 this arrangement was under trial and may have been altered.

P.F. Cells

Position finding cells needed to be concealed from an enemy's view for reasons of safety and careful positioning had to take account of local surroundings. The choice of positions for siting a position finder were few because of the need for a good field of view. The arc of view of the instrument had to cover the arc of fire of the gun it served up to its extreme range. No compromise could be made. The Fire Commander needed to be placed where he could watch the action and give directions to the observers, as well as communicate with the Battery Commanders by telephone. This was often a building of similar pattern to those for observing with additional accommodation for telephonists and orderlies. The position finders were connected to the gun battery by electric cable. This consisted of seven wires for each instrument in order to work the dials, the firing and the signals in connection with this. Telephone wires were in addition. Two instrument wires and two telephone wires were used to connect the transmitting and receiving

stations of a horizontal base position finder. On land the cable was laid in a trench at least three feet deep, more in exposed situations. Special attention was paid to bringing the cables into the battery by a secure route. In Fort Bovisand they were run down the magazine passage and routed up the ammunition lifts. The Fire Comander also was equipped with a special mark of position finder, which differed from the other marks in that it was not connected to the guns electrically.

Gun arcs and pointers

In order to give the gun the range signalled on the dial, an arc and pointer was attached to the gun near the breech, the arc being graduated in yards, calculated specially for the height of that particular gun above mean tide. Various forms of arc and pointer were used and in some cases a clinometer was attached to the trunnions. The training was given by means of a pointer attached to the gun and a training arc let into the floor, graduated in degrees and quarter degrees. (A quarter of a degree would make a difference of 4.4 yards at 1,000 yards range) The arcs were fixed to the floor by means of screws set in small blocks. The Royal Engineers were responsible for these fittings and a great deal of trouble was experienced with fitting them accurately. As some of the old platforms did not fit the racer too well, the guns tended to go askew as they were run around for line, giving erroneous readings. In these cases an average of several readings was taken. The later platforms proved to be more accurate fits. The zero line of the training arcs in all new works was true north; that is any gun laid true north should have had its pointer at zero, and any two guns whose pointers were at the same degree should have been parallel. Every battery needed to lay down a meridian line, and to take bearings on prominent distant objects which were within the arcs of training of the guns. The number of the graduation at some points in each training arcs could thus be determined and the arcs fixed accordingly.

Programme of the 1885 Plymouth trials On 21st. and 22nd. October 1885 the trials of the Watkin Depression Position finder took place at Bovisand Fort. Its purpose was to meet the requirements of elevated batteries the height above the waterline being taken as the base from which the ranges were obtained instead of a long horizontal base with an observing station at each end. The necessity for the two observing stations and communication between them and between them and the battery was thus obviated, and the operation of position finding much simplified. The instruments consisted of one Position Finder connected up with two dials, one of which was in the observing station, and one in the casemate in a convenient position for working a group of two guns. Arrangements were made for both electric firing and firing by word of command. Two targets were moored at ranges of 2,000 and 3,500 yards respectively and a target of special construction was provided which was towed across the range by a steam launch. The programme to be followed consisted of

1. A test of accuracy of the instrument by observing the two targets and any fixed objects of which the exact range was known.
2. Manning the guns and by means of the instrument, following the towed target, firing by word of command and electricity as if in action, but looking over the sights in order to check the results.
3. Repeating 2 laying on two or more vessels manoeuvring in front of the battery; changing from one to the other and noting the time taken to pick up the fresh vessel.
 - a) As with two observers, an officer pointing out the ship to be engaged.
 - b) As with one observer and a commanding officer's lookout, a vessel being picked out by the latter and its position, indicated by bearing and range, communicated to the observer; the time of the various operations to be carefully noted.

For the firing trial the projectiles used were studded common shell, mark II with gas checks, plugged using charges, full, 70lb P. Firing at the towed target using

- a) Service laying - 5 rounds
- b) Using position-finder, firing by word of command - 5 rounds
- c) Using position-finder, No.1 looking over sights and firing by word of command - 5 rounds.
- d) Using position-finder, electric firing from observing station - 5 rounds
- e) Spare rounds to be expended as settled by Committee on the spot - 10 rounds.

Careful note was to be taken of the trial of the comparative advantages of the various methods of carrying out the practice, speed, simplicity, immunity from chances of accident and accuracy obtained. The effects of concussion on the instruments was also to be carefully noted.

Results of the trial at Bovisand Fort

The range on the second day was so hopelessly blocked by sailing craft that three rounds per gun only were fired.

First day. The ranges of various objects were taken with satisfactory results. as it was found difficult to make accurate notes of four guns in a group the centre pair were used for carrying out the program, but detachments were drilled and projectiles brought up & co at one of the flank guns during the first days experiments in order that there might be the same amount of noise as if all the guns were in action. The guns were then laid on HMS Harpy, which steamed two and fro across in front of the battery. The words 'ready' and 'fire' being given by the officer in charge of the group who also read to the numbers 1 the changes in line and elevation as they appeared on the dial. Drill tubes only were used and an officer looked over the sights at the moment of firing. The results were on the whole satisfactory but from a slight want of adjustment which was rectified before the next day's experiments the guns in this and the next series

were always directed to the left of the object. There was also a discrepancy between the graduations on the tangent scale and the cardboard slip attached to the arc amounting to 100 yards in one gun and 150 in the other. With practice and more accurate drill it was considered that this class of firing might be fairly successful but it is by no means easy for the officer in charge of group to lay his guns sufficiently ahead of the moving object to compensate for the time taken to lay make ready and fire, and also to correct for time of flight and drift. Electric firing with tubes only was next tried the guns being as before, but fired from the observing station on receipt of the ready signal. This was not satisfactory as by the time the guns had be laid and the signal ready appeared in the observing station the ship had changed her position, and the projectile would have fallen astern. It was moreover impossible for anything like an accurate allowance to be made by the officer working the instrument or the officer commanding the group. It was noted that in estimating the number of dials required in a fort one should be provided for every two guns it being extremely difficult to give intelligible orders to more than that number.

Predicted electric firing was then tried with excellent results, the guns in each instance being so laid that the sight were actually directed on the bows of the target vessel at the moment of firing. neither of the series in para III of the programme was carried out as there was evidently no difficulty whatever in picking out any particular and laying the guns of the group on it.

Recommendations

Following the trials at Bovisand Fort Plymouth the Special Committee on Range Finding made recommendations as follows :-

1. *The trials have clearly demonstrated the absolute necessity for some system for position finding. I am of the opinion that the results obtained*

were eminently satisfactory taking into consideration the the want of experience of both officers and men and the limited time available for preparations and preliminary practice. Not only is the system especially valuable in casemated batteries mounting many guns as in the case of Bovisand but as a means of concentrating isolated guns on any particular ship at the will of a commanding officer in a central station it will also meet the requirements of more modern armaments and increase to a very sensible degree the effective fire of a fortress. I therefore recommend the adoption of the Depression Position Finding system proposed by Major Watkin.

2. Some minor modifications have been proposed since the experiments by Major Watkin and Captain Golden RA which will simplify the construction and working of the instruments and which consist in the combination of the position finder with the dial in the observing station and in a reduction in size of the dials. The first alteration obviates the necessity for two observers and the second lessens the risk of injury to the dial while diminishing its costs. These modifications will necessitate a further trial before an order can be given for the supply of instruments but need not delay the general preparation to be proceeded with for the adoption of the system at Fort Bovisand, where electrical communications and observing stations may be prepared at once.
3. The other sea defences should be similarly be prepared in order of their importance or convenience.

Brigadier Hogg in 'Artillery its Origin, Heyday and Decline' cites a story that Watkin was instructed to attend a special course for officers undergoing training in the use of the depression range finder. He failed. Hogg believed the story to be a hoax as Watkin became Chief Inspector of Position Finding on 1st. April 1896. In fact Watkin was himself responsible for the

training. The Special Committee on Range Finding had recommended the adoption of his system and as soon as it was completed in one battery all officers in the district were to be instructed in its use.

4. It is further necessary that as soon as one battery is completed a large number of, if not all, the officers in the district should be fully instructed in the use of the instrument. For this purpose it is recommended that Major Watkin's services should be secured for at least three years. He will also at times require the assistance of a good electrician like Captain Holden RA and arrangements should be made to secure this officers attendance where necessary.

Watkin, posted

Major Watkin was posted to the Department on 01/04/86. The Director of Artillery on 13/1/87 directed the sealing of the pattern of 'Mark Ia Range Finder, Watkin, with case and tripod stand'.

Watkin D.P.F.s adopted

In 1887 following more trials at Plymouth the Watkin depression position finder passed its final trials with great success and although it underwent several changes and modifications no time was wasted in applying its use generally to coast defences. Lewis described the invention as :-

the most important adjunct to coast batteries yet invented, and one which without any exaggeration multiplies several times the value of any gun to which it is applied. It was, he said, an instrument by which a gun can be directed with the greatest precision on to a spot at which it should be fired in order to strike a vessel, even if the latter be in rapid motion, and which provides for its being discharged at the right moment.

Siting the D.P.F.

It was recommended that the observing stations in which the instruments were to be placed should be situated well clear of the work if possible to the right or left and never immediately above it. They were to be so designed and placed as to be concealed from the enemy and out of the probable line of his fire. Two sets of observing stations were to be provided in order that one set should be available should the view from the other set be impeded by smoke. As the instrument now provided required no chart table the expense of these stations would be very trifling and therefore there should be no difficulty in increasing their number as proposed. The guns in the work were to be divided into groups, the number in each and their distribution to depend on the contour and structure of the battery. As all the guns in a group were to be laid with this system with their axes parallel, the outside guns of any group were not to be further apart than 100 feet horizontally. Each group required a Position Finder and dial, the latter to be placed in a convenient position in the centre of the group. The instruments were to be connected with their dials by means of a five core armoured cable efficiently protected from interruption by either the enemy's fire or other causes. The instruments require only four wires but the fifth would be available for a firing wire or in the case of interruption for any of the others.

D.P.F. proposed sites

The depression position finder was recommended as being applicable to the following stations :-
 Portsmouth; Needles passage, Dover, Portland, Malta, Gibraltar.

The totals of Instruments were

Plymouth	30
Portsmouth	8
Dover	6
Gibraltar	20
Malta	30
PortlandBreakwater	12

Grand Total £50 per instrument plus costs £16,305. It was proposed to add Cork, Forts Camden and Carlisle, Aden

and Bermuda to the lists of stations to which Depression Position finders should be supplied.

- 5 to Cork
- 5 to Aden
- 8 to Bermuda

An 1886 report on the defences of Malta found that choices of sites for the D.P.F. were limited. For Sliema and Cambridge batteries the only possible positions appeared to be the flat roofs of the houses in rear of the batteries where they would be indistinguishable in the mass of buildings. The height of the coastline of Malta is so low that the horizontal position finder was considered necessary for the new long range guns.

Electric Position Finder

The electric position finder proposed by Major Watkin for Fort Bovisand and Picklecombe in 1887 used the same pattern range table as that for the depression position finder being used in the battery. The observing stations could be wholly outside the fort as in the case of the depression position finder, one of these observing stations however needed to be of suitable dimensions for holding a chart or chart table. These instruments were only intended for works having less command of 60ft. above mean tide level. the arrangement for grouping the guns and for communication between them and the guns was to be the same as for those of the depression position finder. Three observing stations were required. two of these needed to be clear of the fort right or left and the third at such a distance as to give an effective working base. Watkin proposed The following stations were to be supplied with electric position finders,

Portsmouth	
Spithead Forts	9 @ £60
Sheerness	4 @ £60
LandguardFort	3 @ £60

Sources

Permanent Fortification for English Engineers - Lewis

Coast Defences of England and Wales 1856 - 1956 - Ian V. Hogg.

Handbook for the 9-inch RML gun and mountings 1899 H.M.S.O.

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Manual of Coast Fortress defence - 1914 - PRO Kew WO33/697

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Once more I am grateful to Robert Christmas for helping me with the applied maths that is necessary to understand the intricacies of range finding.

In a future article I will attempt to explain the working of the Position Finder in more detail and describe the arrangements as found in Fort Gilkicker.

VOLUNTEER ARTILLERY 1888

Report on the Account of Army Expenditure from 1888 to 1889

211c The Volunteer Artillery received during the year a most important addition to their equipment in the shape of no less than 226 guns. Many of these guns were required to replace others from various causes but amongst them there were sufficient to enable the authorised re-organisation of this arm of the service to be carried out to the following extent:-

27 x 40pr. RBL

7 x 20pr. RBL

33 x 16pr. RML

all batteries of position

Carriages for all these batteries were also provided and a proportion of ammunition wagons and ammunition and store wagons, also equipments according to approved lists and ammunition at the rate of fifty rounds per gun. Further provision of ammunition up to 200 rounds per gun was also proceeded with but supplies cannot be completed until accommodation is furnished at the centres for mobilisation. These issues represent in stock value about £87,000

Taken from WO33/45 PRO KEW