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Publisher: Routledge
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Royal United Services Institution. Journal

Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/rusi19>

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Published online: 11 Sep 2009.

To cite this article: T. J. Haddy R.N. (1894) Electric Light Projectors for Coast Defence, Royal United Services Institution. Journal, 38:193, 326-334, DOI: [10.1080/03071849409416994](https://doi.org/10.1080/03071849409416994)

To link to this article: <http://dx.doi.org/10.1080/03071849409416994>

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ELECTRIC LIGHT PROJECTORS FOR COAST DEFENCE.

(Translated from the "Rivista Marittima" for January, 1894, by
T. J. HADDY, R.N.)

General Remarks.—When the electric light projectors were introduced on board ships with a view of discovering the enemy and guarding against sudden and secret attacks by torpedo-boats, many other useful applications were found for them, and it would appear that one of the most important of these is the defence of the coast, for which service they were very soon appropriated, so that at present we may say there is not a single harbour of any importance in the defence of which a certain number of projectors are not employed, and which are generally of a more powerful description than those fitted on board ships.

Although many years have passed since their introduction, and numerous experiments and accurate researches have been made by the principal navies of the world, we cannot but admit that even now great uncertainty still exists in the opinion of the most competent judges, both as regards the value of this arm of the defence and the best method of employing it. It is very certain, however, that the ranks of its adversaries have been constantly increasing, and have now become most formidable. They do not as yet call for its abolition, but assert however most positively, that the projectors should not be used on board ship except in special cases, and that the unconditional employment of them instead of being useful is always exceedingly dangerous. These are serious questions, which deserve the most accurate study and the fullest enquiry, and which would perhaps lead to results which would be indisputable, when we consider that, unlike other arms, they can be tested under conditions almost identical with those which would obtain in real warfare. The projectors destined for coast defence certainly merit the same attention as those which are carried on board ships.

Necessity for various kinds of Projectors.—The projectors for coast defence are employed under more favourable conditions than others, for the following reasons:—1st. They can nearly always be placed at a distance from the fort or battery the target of which they are called on to illuminate, and so that the position of the observer is the most favourable one possible. 2nd. They are not subject to restrictions of weight and space, and can consequently be more powerful than those on board ship, with increased efficiency. 3rd. For the reasons stated above, an arrangement can be adopted which affords protection for the engine and dynamo, the conductors, and also in

part for the projector, leaving only the lens itself exposed. In certain cases the latter could also be protected, and the luminous rays still usefully employed. The conditions by which the number of projectors on board ship is limited do not exist on shore, where the number can be determined in accordance with the necessities of the locality it is wished to defend. We may, therefore, allow ourselves to be guided in the determination of this question entirely by the considerations which we will bring forward. We consider that a projector cannot be expected to yield satisfactory service unless a well-defined task is assigned to it, clear and precise in every circumstance; and considering the numerous services which are required of projectors in the defence of a harbour or roadstead, we should apply to them the principle of the division of labour. We shall then have projectors for the protection and working of the obstructive defences, those for searching the horizon, and finally those destined for illuminating the ships of the enemy when discovered, in order that the guns of the forts may be brought to bear on them. With a view of clearness we shall name these three descriptions of projectors—mining, exploring, and aiming projectors. The first will illuminate the launches, torpedo-boats, and small vessels which may attempt to interfere with the obstructions, so as to keep them under the fire of the batteries told off for the protection of these obstructions, and also to show up any ships which may attempt the passes protected by observation mines, so that the latter may be exploded at the proper instant. It will be seen at once that the duties entrusted to these projectors are sufficiently numerous and important, and that the efficient performance of them would be seriously compromised if the duty of exploring the horizon were to be added. Indeed, if these two services were to be entrusted to one single series of projectors, the enemy's ships might, by drawing attention to themselves, monopolise their action, and so leave a free field for swift launches and torpedo-boats to play havoc with the obstructions by means of grapnels, small torpedoes, &c. By showing themselves for short and flying intervals at a distance of 4,000 metres from the projectors, the ships would be visible with difficulty and very indistinctly, and the defensive batteries would hardly risk a shot at them from the great uncertainty of aim they would have. If the times of their appearance were well chosen, and the atmospheric conditions favourable to them, fast ships would have very little to fear from the attacks of the torpedo-boats of the mobile defence.

There is also another reason for the institution of the first two kinds of projectors; we shall see presently that with a given position of battery, observing station for mine field, launching station for torpedoes, &c., there is a certain position for the projector detailed to discover the target within the field of action covered by those works, which is distinctly preferable to any other; and since forts, observing stations, &c., have different positions and fields of action it follows that a projector should be attached to each for exploring services. If, however, the various works of defence are so close to each other that they may be considered as a whole, and all operate on the

same zone of the sea, a single projector may be sufficient; this, however, cannot be the case with forts (which nearly always have a very extended field of action), in conjunction with groups of batteries for the defence of the obstructions, observing and launching stations, &c., which have a field of action more internal and limited, hence the necessity of having the two systems of projectors before named. Besides this, it is very certain that searching the horizon by the projectors destined for this service would have to be continued after an enemy's ship had been discovered, hence the necessity that the fort or group of forts commanding the zone in which the ship is discovered should have a projector attached exclusively to this fort or group of forts so as to keep their target constantly illuminated, and at the same time leave the work of exploration to be carried on by the projector detailed for that service. The reason which justifies the existence of these aiming projectors is as follows:—

Projectors for the Obstructive Defences.—Let A B (Fig. 1) represent a mine field, and C its protecting battery, with this single and well-defined duty only, G C H being the field of action which its guns command; this limitation permits of the protection of the battery from the guns of the enemy's ships in the offing by the earthwork or armoured parapet D; the same advantage may be obtained in the protection of the projectors when their duties are confined solely to the surveillance of the obstructions themselves; they may therefore, for example, be installed at P, and will illuminate the zone E P F, which includes, in addition to the mine field A B, a zone Z in front of it, and such that the least distance $a b$ between the external radius P E of the sector to be explored and the first line of the mine field is at least 1,000 metres. In this way before the boats and light vessels could reach the mine fields and be in a position to do them injury they would be a sufficient time under the fire of the protecting battery; or, in the case of an observation mine, the officer at the observing station would have plenty of time to discover and follow the enemy's ship while she is still at some distance from the mine which it is his duty to explode. The projector would be defended by the armoured parapet K from the guns of the enemy's ships in the open, and from which also by its keeping the source of light out of sight a good object of aim would be withdrawn. It might be objected that a projector so installed might be surprised by launches or torpedo-boats and destroyed, as they could approach in the sector E P L not covered by the light; for this reason an attentive and vigilant service of guard-boats and coast defence torpedo-boats would be exercised in the dark zone, and which would constitute the mobile defence outside the obstructive defences; the steamboats not being disturbed by the electric light would perform a service of discovery really efficient, and would engage the boats of the enemy which might attempt to interfere with the obstructive defences. A few machine-guns in the neighbourhood of the projectors would defend the approaches both from the sea and shore against any enemy rash enough to attempt to take them by surprise by a night attack.

Exploring and Aiming Projectors.—The exploring and aiming pro-

jectors are more subject to destruction by the guns of the torpedo-boats and light ships of the enemy in virtue of their exposed position. They should therefore be protected as much as possible; they should never be so installed as to be exposed to direct attack, by which I mean to the destructive effects of projectiles falling in their immediate vicinity; they should not therefore be placed on ramparts of masonry, neither inside nor in the neighbourhood of old churches, castles, towers, &c., where they would run the risk of being buried in the ruins caused by shell fire, and never so that there are walls behind and above them.

The projector should be protected by an armoured parapet or other defence in such a way that the lens alone, from which the beam of light issues, remains unprotected from the shots of the enemy. An armour-shield similar to that employed for the protection of light guns moving with the projector, and provided with suitable apertures, would serve to protect it and also the operator as well. A disappearing installation will also give good results when arranged so that it allows of the projector being worked under cover, leaving only the reflecting mirror exposed. In determining the position on shore for the projectors for the defence, care should be taken that in working the light for searching purposes the beam does not fall on any of the other defensive works, as this would not only render them visible to the enemy, but would also place the gunners and every other observer in the worst possible condition for carrying out their duties. The alternation of dazzling light and almost total darkness, injurious to all, would be exceptionally so for the officers in charge of the observation mines, as they would be able to see nothing beyond their own immediate surroundings. It would be a grave error too to place a projector inside a battery, from the disturbing effect it would have on the aiming of the guns in certain positions of the beam, besides which it would afford the enemy a good target and enable them to direct their own guns on the battery. Here we might consider (although we have not much practical experience to go upon) that the aim against a projector would always be a very certain one since the gunner, if provided with suitable coloured glasses, could see and keep the sights on the source of light, even when it is turned directly against him.

Curve of Visibility.—Choice of the Locality in which to establish the Electric Light Station.—It does not need a long argument to show that nothing disturbs an observer more than a source of light close at hand, and which strongly illuminates the objects in his immediate vicinity when he is intent on discovering objects at a distance. For this reason a position near to the electric light projector is an unfavourable one for an observer; we can therefore assert so far that a projector should be placed at a distance from the works whose target it is its duty to illuminate; but on what bearing? Let P, fig. 2, be the electric light projector, PA the direction of its beam, and let us make PA fall on any target whatever, keeping the axis of the illuminating cone constantly on it; for example, at B; an observer situated at P, near to the projector, would then lose sight of the

target; let the same observer, starting from B, take the various directions BC, BD, BE, BF, BG, &c., making with PB the angles $PBC = 15^\circ$, $PBD = 30^\circ$, $PBE = 45^\circ$, $PBF = 60^\circ$, $PBG = 75^\circ$, &c., and determine the different points H, K, L, M, N, &c., at which he loses sight of the target; by joining these different points we shall obtain a curve which we may call the curve of visibility. We shall find that the curve KLM approximates very closely to an arc of a circle having its centre at B, and the radius $BK = BL = BM$ equal to about six times PB, the distance between the projector and the target. This is the only experiment as regard the researches for data in the employment of the electric light which has a general character; the results always verify each other under any atmospheric conditions, and independently of the observer or of the material employed; the only condition necessary is that all the other conditions remain constant during the period of the experiment. From this we may draw the conclusion that *the most advantageous position for an observer with respect to a target illuminated by the electric light is such that the line drawn from his position to the target makes an angle of from 30° to 60° with the beam of the projector.* It is not to be concluded that to maintain this favourable position will necessitate a considerable limitation of the zone of exploration. For example, let us construct (in fig. 3) a right angle triangle at PBPO, the base BP = 3,500 metres (the maximum range of exploration), the angle PBO = 30° , and let us suppose the projector at P, the target at B, and the observer at O; describe a circle passing through the three points B, P, O; it will have its centre at A, the middle point of the hypotenuse BO, and PAO will be = 60° . Let us describe a second circle through P, A, O; now, for all the points comprised within the figure in hatched lines, the straight lines from them to P and O will form angles varying from 30° to 60° ; for those comprised within the figure in dotted lines the above conditions will not hold good, but when we consider that their greater proximity to the projector will more than compensate for the unfavourable conditions in which they are placed, we shall see at once that they may also be included in the sector of exploration, which will result in this sector BPC being equal to 60° ; which is sufficient as we shall see hereafter in considering other conditions which limit its extent to a range not greater than this; the positions of the observer and projector being fixed we shall have another sector B'PC' similar to the first. It is very certain that the reasons for deciding the choice of position for an electric light installation will be so many and various that we shall be obliged to take only a relative account of all that we have brought forward. In order to fix the position of the projector for any defensive work it is necessary to determine its range, to do which would require numerous and difficult experiments, and in carrying them out we should have to take account of most variable conditions, and which it would not be possible to include in our calculations by the substitution of any coefficient whatever, as, for example, the state of the sea and atmosphere, the height of the projector above the sea level, the nature and colour of the target, and

the manner in which it is presented, &c. We may say, therefore, that the projector has no fixed range, as any of the above causes would be sufficient to modify it; besides which, as we see on the first experiment of which we treated, the position of the observer influences the effective range of the projector; it is clear, then, that in this particular it is impossible to obtain data of a precise and general character, but if we had the results of numerous and patient researches to guide us, we might be able to deduce from them consequences of the greatest advantage to us. I maintain, in conclusion, that it is absolutely useless to extend observations beyond a range of 3,500 metres for projectors of 90 cm. (36 in.) and 70 ampères, which are the prototype of those used for coast defence. The rapidity with which the efficiency of the projector diminishes with increased distance from the object it illuminates is well known, and must be taken into account when choosing the site for the installation of a search light installation; we cannot, therefore, think of placing the observer nearer to the target than the projector is; which principle applies also to the defensive works.

Both the projectors for the protection of the obstructions and those for discovering the enemy's ships must be situated at the least possible elevation above the sea; for whilst it is of the greatest advantage on the one hand to preserve the inclination of the beam to the horizon constant, yet, on the other, it is obviously desirable to leave the dark zone near the coast immediately under the beam as small as possible in extent, and it is therefore clear that the lowest elevation is the best; in practice, however, we must adopt a position which protects the projector from the wash of the sea or spray during bad weather. For projectors which serve to illuminate the targets for the heavy artillery the same conditions do not hold as for the others, and for them the greatest elevation possible is to be preferred. The intersection of the beam and the ship illuminated will, in this way, result in a larger area of illumination, and it will increase with the increase of the angle of incidence and with the increase of elevation of the projector; more than this we shall have in the projection of the beam the illuminated surface of the upper deck of the ship, which is generally light in colour, and will increase the visibility of the target from the batteries.

Method of using Projectors for Coast Defence Purposes.—The greatest uncertainty still exists amongst the most competent judges on the employment and arrangement of projectors for harbour defence, but from what we have stated in this article, one thing is clearly manifest, and that is, that any method of using a projector would be preferable to that which leaves it in the hands of the person who operates the working apparatus, that is, who is placed in the immediate vicinity of the source of light; to this, however, we are forced to submit when the projector is not in communication with an observer conveniently situated. An ideal arrangement would be that which would permit the observer himself to work the apparatus when placed at a distance from it, but in default of this we must have recourse to the telegraph or telephone, as it is evident that

instantaneous transmission is required in order to control a projector efficiently from a distance; the telegraph is, therefore, advisable only as a safe method of communication and which leaves a register of itself, but it does not answer the conditions. There is no doubt but that the telephone must be adopted; the receiver must be situated in a quiet place so as to avoid repetitions, which would cause a loss of time and make the connection itself useless. Close to every electric light station there should be a chamber, which should also serve as the storage room for the projector, in which all the telephonic communications should be collected; the attendant receiving the messages at the telephone should transmit the orders to the person in charge of the training and elevating gear at the projector, either by calling them out loudly, or by means of a voice tube; in the same chamber there should be an observer for the illuminated zone, to assist the one stationed at a distance in giving instructions to the man working the projector. The principal services which may be assigned to a projector are the following:—1st. To discover a ship within a given section of the horizon. 2nd. To follow the target with the beam of light. The best way to use a projector for the purpose of discovery is undoubtedly that in which a fixed depression calculated as a fraction of its height is given to the beam of light, and such that the inclination of the illuminating cone with the surface of the sea will produce an illuminated ellipse with its major axis in the line of the beam equal to 4,000 metres, and the projector should be worked with a uniform angular movement. The velocity of this movement should be such as to cause it to pass twice over any ship which might cross the zone commanded by the projector, in the direction of a chord of the sector, at a speed of 18 knots. If the extent of the sector is so great as to necessitate a too rapid angular movement of the projector, it should be divided between two, and for this reason as a rule the extent of the sector assigned to any single projector should not exceed 60°.

To follow an object when discovered with the projector does not offer any difficulty when the observer and the person working the apparatus is one and the same individual, but when this is not the case the operation becomes an exceedingly delicate one, and it is a bad case if there are two or more observers watching the target, and giving instructions to the man in charge of the light; there should be perfect accord between the observer and the latter, who should know exactly what is meant by the orders "easy," "smartly," &c., which necessitates constant exercise with a fixed personnel.

It is certain that a really efficient employment of projectors can only be obtained by having them controllable at a distance. Another important question arises, Should the projectors for harbour defences be kept continuously in action during the night? Admitting that the position of the electric light installations is perfectly known to the enemy, the continuous action of the projectors will carry with it the following disadvantages:—

1st. It will allow the enemy to reconnoitre from the offing every locality and prominent point, to determine his exact position on the

chart, and as a consequence the exact distance of the various defensive works.

2nd. Friendly guard-boats, torpedo-boats, and small vessels will be frequently under the light of the projectors, and whilst it would render their task of attack by surprise most difficult, it must often happen that they will form a most favourable illuminated target for the guns of the enemy's ships, and which they, surrounded with light, will not even be able to see; in other words, the movable defence (constituted almost entirely of torpedo-boats, a defence in which naval officers have very much more faith than in the fixed defences, and with good foundation for their confidence) would be obliged to carry out its duties under conditions absolutely unfavourable; when the particular local conditions do not admit of this danger being avoided, I think we need not hesitate to affirm that the projectors should *not* be kept continuously in action, but kept instantly ready for use when the presence of the enemy is notified by the exploring ships or guard-boats.

In addition to keeping the projectors obscured, when we can also succeed in suppressing every light visible within a certain distance, such as from houses, lighthouses, factories, &c., on dark and rainy nights, which are just those in which isolated and limited attacks by surprise are most to be feared, we shall render the enemy uncertain and hesitating in his attack, and enable the boats of the mobile defence to operate under more favourable conditions. It may be objected that this obscurity will also be injurious to the ships of your own side in case it should be necessary for them to enter the protected harbour, but it must be admitted that their commanders will be more familiar with the locality than those of the enemy's ships; besides which it would be easy to establish a temporary light in a convenient position, which should only be shown when a ship, known to be friendly by means of private signals, requires to enter the harbour. The ships and torpedo-boats of the exploring service should be furnished with a 40-cm. (15½-in.) projector, ready for action but completely obscured, so that when the beam is thrown on the ship or boat discovered, it not only announces the fact of the discovery, but also the direction and nature of it. In order not to expose herself to certain and swift destruction, the light should be obscured every now and then, and a rapid change of position effected before again putting it in action; the ship could in this way be fought efficiently by the other torpedo-boats which would operate under cover of darkness; and if she should take to her heels again this will be the time to put into action the projector of the fixed defence, in order to show her up for attack by the batteries to which they are attached. The launches and guard-boats in the zone outside the obstructions should also be supplied with 35-cm. (13·8-in.) projectors, which they could use as above for discovering the enemy's torpedo-boats and small vessels which may invade their territory.

In conclusion, I consider that accurate study and patient research and experiment are still necessary on the subject of the installation and employment of projectors, and am convinced that the conclusions

arrived at would show that greater confidence should be placed in them, and that it is necessary to employ them much more largely than at present for the purposes of coast defence. It is certainly necessary to dispel all that is at present indeterminate and uncertain in the use of this particular arm of the service, which, seeing that it always and continuously reveals its presence at the same time as its efficiency, may easily become dangerous rather than useful to its friends.