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THE NEW DEFENCES OF COPENHAGEN.

BY

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(Translated by Captain M. Nathan, R.E.).

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PAPER I.

THE NEW DEFENCES OF COPENHAGEN.

By Lieut.-Colonel H. Frobenius.

(Translated by Captain M. Nathan, R.E.).

Since 1871 the great States of Europe have rivalled each other in the preparation of their armaments and the energetic development of their fighting powers, in order to be perfectly prepared for that generally anticipated war of nations which, when it comes, will embrace the whole civilized world. Meanwhile, the lesser States have not lagged behind. The instinct of self-preservation and the not ill-grounded fear of being drawn into and swallowed up in the great struggle have been an incentive to mighty efforts. The times are indeed past in which even a small State might cherish ideas of conquest, when by cleverly taking advantage of the political conditions, and by the bold enterprise of land or sea forces, such a State might extend its power and increase its territory. The result lies now in the hands of the big Powers, and the small States, to whomsoever they may attach themselves, have nothing to gain. They may generally count on the ingratitude of more powerful allies, and, apart from this, it is in accordance with the spirit of historical development that every armed conflict should injure their independence, and bring nearer their absorption by the greater nations.

The small States cherish, therefore, only the one wish to keep out of the conflict of arms, and to withdraw wholly their adherence from each and every great Power, that is, to be absolutely neutral. Since, however, at no time could the protection of guaranteeing Powers be less reckoned upon than at present, since these Powers would all themselves be involved in the war, it is only an armed

neutrality that remains possible for the lesser States. For this reason Belgium, and also Switzerland, have undertaken the re-organization of their fighting powers, and the re-construction of their system of defences; for this reason Denmark has newly fortified its capital, and will sooner or later set to work to re-organize its army. Denmark is, properly speaking, not neutral; it is neither bound to nor guaranteed neutrality. If, therefore, it desires to secure against all attack the neutrality it has itself chosen, the preparation of its means of defence, and the protection of its most important possessions, are so much the more necessary.

The fact that such preparation and protection are essential for its safety can only be properly appreciated when travelling through its rich fields and along its accessible frontiers, lengthened by arms of the sea, bays and fjords, and penetrating right into the interior of the islands. Only a small and diminishing portion of the frontier is open to land attack, and Germany, the only frontier State that enters into the question, will, on the completion of the North-East Sea Canal, have very little interest in threatening this frontier. But this makes the waters and harbours of Denmark so much the more important for the maritime nations involved in the European war. It does not lie within the present task to discuss the advantages which this or that great Power might derive from the occupation of Denmark, or of a portion of its territory. A glance at the map will show which of the Powers these might be, and the use they might make of the Danish waterways and harbours. It is also obvious that the capital, Copenhagen, in its favourable position on the Sound, with its excellent harbours, factories, store-houses, war material, and food supply of every description, forms the most important and desirable objective in the country.

The first task in connection with the defensive system was obviously to protect the town and harbour of Copenhagen against every possible form of attack by land and sea. This work will be finished in its entirety in the course of the present year, and it is to be anticipated that defences on a smaller scale will now be provided at other points of the coast which particularly invite seizure by an enemy; the experience gained in construction at Copenhagen will enable this to be done under particularly favourable conditions, especially as regards design.

The Island of Seeland, at its north-eastern point Helsingör, approaches so near to the Swedish coast that the waterway of the Sound is there narrowed to a breadth of $2\frac{1}{2}$ miles; to the south the

arm of the sea broadens out rapidly, and at Copenhagen, 50 miles from Helsingör, attains a breadth of 17½ miles. To the south of the capital the Danish coast trends back to the west, and forms the Kjöge Bay (*Plate* I.); this results in a further broadening of the arm of the sea; at the same time there is a separation of this southern water area from the northern part of the Sound, the so-called Oere Sound, by two islands, Amager and Saltholm. The former hangs like a pear from the angle of the coast, at which lies Copenhagen; it is 9⅓ miles in length from north to south, and about 4 miles in maximum breadth. It is separated from Seeland only by a narrow arm of the sea about 1,100 yards broad on the north, and widening to 3¾ miles at the southern end; it is, moreover, blocked by shoals, between which winds a narrow canal-like channel 8 to 11½ feet in depth. At the northern end of Amager, the town of Copenhagen, taking advantage of patches of firm ground and shoals, has spread on to both islands, leaving for the harbour only a space of open water about 550 yards wide between the two parts of the town, Friedrikshavn on the Seeland, and Christianshavn on the Amager, side. Also to the north of Amager, big sand-banks lie in front of the coast, and narrow the entrance of the harbour to a small but deep creek.

About 3 miles to the east of Amager lies the Island of Saltholm, some 4½ miles in length from north to south, and 2 miles in breadth. The Drogden Deep, which separates the two islands, and is narrowed by sand-banks on both sides to an open channel of 1,650 yards, is divided to the north of the two islands by a big wedge-like sand-bank, the so-called Middle Ground. The western channel between the shallows of Amager and the Middle Ground is called the Konge Deep, and is nearly three-quarters of a mile wide; the eastern channel between the Middle Ground and the banks of Saltholm is the Holländer Deep, over three-quarters of a mile in breadth. To the north of the shallows of the Middle Ground and Saltholm (about 2½ miles to the north of the citadel of Copenhagen) lies the open water of the Oere Sound. Finally, a broad and important arm of the sea between Saltholm and the Swedish coast forms a third channel, called the Malmö Deep.

I.—The Land Defences.

The old land defences of Copenhagen consisted of bastioned fronts, with broad wet ditches both on the Seeland and Amager

sides; a citadel lies at the northern end of the Seeland defences, and, situated at the entrance to the harbour, has also hitherto formed an important part of the sea defences. It still exists, with its five bastions, low rampart, covered way, and wet unrevetted ditches. The sea-fronts are still armed, but the guns, at any rate those that are not concealed from curious observers by wooden sheds, seem only to be retained for allaying the fears of nervous inhabitants, and for the amusement of the children that play around them. They certainly could not be fired from their present worm-eaten and shaky carriages. From the carelessness with which the citadel is treated and entirely thrown open to the public, compared with the care with which all the new fortifications are guarded, it may be inferred that it will soon follow the fate of the Seeland town defences, and be converted from a menacing fortification to a harmless boulevard. The only reason for its still being in existence is no doubt the fact that the sea defences are not yet finished. It will disappear with the completion of the Middle Ground Fort. Then the Amager lines, about 4,000 yards long, with 13 bastions, will be the only part of the old town defences remaining. They appear to be amply sufficient to protect Christianshavn against a *coup-de-main*.

Fredrikshavn has developed in a wonderful way in the last decade. It has long spread beyond the area, about $1\frac{1}{2}$ miles in length, and three-quarters of a mile in depth, enclosed by the old fortress walls, so that with its suburbs it now covers a space of which the radius is 4,600 yards, and the longest chord nearly $4\frac{1}{2}$ miles. The population probably considerably exceeds 300,000. In order to protect this populous and prosperous town and the important harbour, the engineer had to carry his works of defence well to the front. This was much facilitated by the fact that the whole circumference of the town had not to be protected, which would have involved for each advance of 1,000 yards to the front an increase of 6,000 yards in the length of the defences; it was only necessary to deal with a sector, which, from the formation of the coast, includes an angle of about 128 degrees, and so is only a little over a third of the complete circle. A radius of rather more than 7 miles was given to the line of defences, which were thus kept 8,000 yards in advance of the suburbs, and securing the harbour against every possible bombardment from the land side, attained a total length of about 16 miles.

By ascending the round tower of the Trinity Church, which is 117 feet in height, a view is obtained of an extraordinarily fertile

and well-cultivated country, in which villages appear like wooded islands, spaced at nearly regular intervals of about $1\frac{3}{4}$ miles from each other in the stretches of meadow and field; between them are a number of single farmsteads, sprinkled like green dots, and testifying to the productiveness and economical organization of the country. All these places are hidden among green trees, and towards the north-west and north, where wooded heights limit the view, these localities can hardly be distinguished from the woods. In this direction are to be sought the newly-constructed forts, which have such small relief that they will in time become indistinguishable from the surrounding ground. When the plantations on their glacis have grown up it will be impossible to tell them from the many green patches sprinkled over the terrain.

If an imaginary line be drawn in a westerly direction from the above point of view, the ground to the south of it as far as the coast of the Kjöge Bay (about $5\frac{3}{4}$ miles along the defensive position) will appear nearly entirely level, while to the north of this line it rises into rounded slightly-wooded plateaus and ridge formations which connect with the heights surrounding the Füre Lake, and continue thence to the coast of the Oere Sound, and in the far north-west appear to culminate in several more considerable elevations. It is, however, not so much well-defined pronounced ridges which give character to the formation of the ground as the depressions which intersect and articulate it; these depressions run generally in a north and south direction from the heights of the Füre Lake down to the coast, sometimes in narrow gullies, sometimes in broader marshes and water-covered tracts, working themselves into the forms of the higher ground like bays and estuaries.

The most important of these lines of depression rises $1\frac{3}{4}$ miles to the south of the Füre Lake (distant about $9\frac{1}{4}$ miles from the harbour of Copenhagen in a north-westerly direction), and is only separated by the flat saddle of Bagsvoerd, 1,650 yards in breadth, from the Bagsvoerd and Lyngby Lakes, which form the southern continuation of the Füre Lake, with which they are connected by a canal. The line of depression, called the Kagsau, runs nearly due south, then turns a little to the east and reaches the coast about $4\frac{1}{3}$ miles to the south-west of the centre of the harbour; the entire length amounts to about $8\frac{3}{4}$ miles. Dividing this length into three equal parts, we find in the first part, west of Husum, a considerable broadening of the depression, which looks like an extensive marsh dotted with islands; several tributary depressions running in from the west and

north-west sub-divide the distant terrain. This part of the Kagsau is separated by the small ridge of Husum from the Utterslev Marsh, which forms the southern termination of a second eastern line of depression.

From the eastern end of the Lyngby Lake, a line of depression (about 3 miles long) runs from west to east, and reaching the shore of the Oere Sound at Klampenborg, forms the southern limit of the Deer Park plateau. The Gentofte depression starts three miles to the east of the Kagsau; it runs parallel to the Kagsau as far as Emdrup, and from there forms an extensive marsh to the west—the Utterslev Marsh. It will be seen that these lines of depression, *i.e.*, the Bagsvoerd and Lyngby Lakes and Lyngby depression on the north, the Kagsau on the west, the Gentofte depression on the east, and the Utterslev Marsh on the south, enclose a plateau, that of Gladsaxe, which is approximately a quadrilateral of 3 miles length of side. Connected with it only by the above-mentioned Husum ridge, a small plateau projects to the south towards the flat plains; this plateau appears as a definitely-marked advanced feature of the northern more broken ground, and comes ultimately to an end in the summit on which stand the park and suburb of Frederiksberg. Frederiksberg attains a height of 66 feet above the sea-level, the plateau south of Husum 86 to 121 feet, the ridge of Husum 66 to 69 feet.

The plateau of Gladsaxe is further intersected by a depression along the south-west to north-east diagonal with a dip in the centre 91 feet above sea-level. The north-western part attains heights of from 115 to 141 feet, the south-eastern, which is the most important mass in the whole terrain, reaches 167 feet, while the Kagsau depression falls from a level of 75 feet at its source to 33 feet at Husum, and 25 feet in the second third of its length. Finally, the plateau of the Deer Park attains a height of 157 feet.

It is at once obvious that the Kagsau depression offers an excellent line of obstacle for a defensive position facing west; the right wing, Gladsaxe plateau, resting to the north on the line of the lakes and depression, obtains a very good commanding view of the foreground, and favourable conditions exist for a position echelonned to the rear, at a distance of over $6\frac{2}{3}$ miles from the harbour. For this right wing the height of Husum, with its exceptionally strong frontal obstacle, affords a very favourable termination to the south, about $5\frac{2}{3}$ miles from the harbour; it fires along the northern part of the Kagsau, and towards the west it sweeps the Harrestrup-Au, a line of obstacle

which cuts through the whole field of attack. After passing Husum the Kagsau approaches so near to the town ($4\frac{1}{8}$ miles from the harbour) that defences along it could not be assumed to furnish efficient protection against bombardment. For this reason the Defence Commissions of 1872 and 1883 decided to push the left wing, starting from Husum, further to the front. The whole line of defence, therefore, forms two salient arcs, of which the furthest points are distant 7 miles, and the intersection at Husum $5\frac{3}{4}$ miles from the harbour. The right wing occupies the high lands and the left the flat lands, Husum forming the central and flanking angle. In the scheme of defence the two wings are treated as being as different in their nature as the ground they occupy, and they must be considered separately.

The defences of Husum consist of a line facing north which spans the whole ridge between the Utterslev and the Kagsau Marshes, a line to the north-west at the edge of the last-named marsh, and a short flank to the south-west where the Kagsau intersects the line of defence. The works have a length of about $1\frac{3}{4}$ miles; they command towards the north the direction from which an attack could most advantageously be carried out after the adjacent forts and batteries had been silenced, the depression of Kagsau, and the other depression which intersects the Gladsaxe Plateau (Mörkhöj); they also flank those lines of depression which would have to be passed by an attacking force proceeding against the right wing. The depressions cannot be considered as obstacles, for they lie, as will be seen from the above description, too high for them to form part of the inundation hereafter described. The water reservoir which feeds this inundation is the Füre Lake, the surface of which is at an elevation of 66 feet.

The western Husum face fires along the valley of the Kagsau and commands the flat marshes in front, which are eventually to be inundated; also the lines of rail and road from Copenhagen to Frederiksund and the marshy Harrestrup-Au. Inaccessible from the front, it flanks the heights, which could be used as advanced battery positions on the western edge of the Kagsau, within close range of the right wing (+38 to 39 feet). Thus the Husum defence, itself commanded by the works of the right wing and protected from being turned, is able to afford considerable support to that wing from its re-entering position.

The left Husum flank has a distinct command over the low-lying defences of the left wing, while at the same time it receives protection from them.

The Husum works consist of an open line of rampart generally polygonal in trace, with wet ditches, flanked by caponiers; traverses, gun-banks, ammunition stores are similar in character to these accessories on the left wing—the west front—which will be considered later. And as in that case, so in this, the line of rampart is not to be looked upon as the artillery position, but rather as a position secure from assault for the safety armament during the first stages of the attack, as well as for the Q.F. and field-guns for special periods of the siege.

The defences of the right wing—the north-west front—consist entirely of isolated batteries; the Gladsaxe plateau is occupied by a double line corresponding with its peculiar formation; in the first line is a row of armoured batteries intended to force the artillery of the attack to bring up its guns to within close range; in the second line, and more commanding position, is a row of open earth-batteries to serve as pivots for the artillery position of the defence; behind is a third line, consisting of an extensive inundation in front of which the whole position of the Gladsaxe plateau appears as a big offensive bridgehead. The defence of the right wing will be considered in detail, proceeding outwards from the interior of the position.

The Lyngby depression is only separated by a narrow saddle from the Lyngby Lake, while the latter is in direct connection with the extensive water reservoir of the Füre Lake. By widening this canal and piercing the height of Lyngby, the water of the lake is led directly into the depression; a big sluice to the westward of Lyngby regulates the flow. The depression of Lyngby is continued in the broad depression which extends to the sea-shore south of the Deer Park plateau. A single broad and deep area of water, divided into separate basins by means of dams, exists here and forms the proper boundary of the right wing towards the north. The extreme right of the wing, the work of Christiansholm, which sweeps the inundation to the west, is situated near the last dam on the shore (by the shore road to Klampenborg); the armoured battery, Fort Garderhöj, takes up the flanking both to east and west at the point where the line of armoured batteries terminates on the inundation, about $2\frac{1}{2}$ miles to the west of Christiansholm. Between the two works of Christiansholm and Garderhöj lies a wooded elevation—Ordrupskrat—which, with two summits, projects so favourably towards the inundation that it has been possible to construct here two batteries nearly invisible from the water's edge on the other side; these complete satisfactorily the sweeping of the

inundation. They lie at a distance of 550 yards from each other; the intervals to the west and east are 2,200 and 1,550 yards respectively. Intermediate infantry works and batteries can easily be thrown up on the favourable terrain.

From this inundation the water is led into the Gentofte depression, which bounds the Gladsaxe plateau on the east, and includes naturally several lake-like basins; at Emdrup the depression divides up, forming on the west the Utterslev Marsh, and sending eastward a branch to the sea. To the south of these depressions and marshes the plateau of Husum stretches from west to east, and, resting on the defences of Husum, forms an excellent secure position against the north, the last defensive position for the right wing.

Following the inundation in its further course, we find it again to the west of the Husum defences in the Kagsau Marsh, which is connected by a canal with the Utterslev Marsh. From the point where the Kagsau intersects the west front the water can also be led into the wet ditch of this front; this, however, is not counted upon, for these ditches can be filled by means of spring water to a depth of $6\frac{1}{2}$ feet or more. In case of need the water of the inundation can also be used for submerging the southern part of Kagsau depression, behind which the left wing would then find a retired second line of defence. Both inundations, that of the right as well as that of the left wing, meet at right angles at Husum, from which results the special importance of this point to the whole defensive system. It appears, however, to be well protected by the inundation, and the available supply of water, which allows the complete system to fill up in three or four days, seems fully to be depended upon. Nevertheless, the defenders have every reason to pay the greatest attention to this part of the fortress.

Fortifications have not been provided for the whole line of the inundation, except where it forms the right wing of the complete system of defences; such works may safely be left to be carried out in time of war. Two small batteries have, however, been erected at that point where the Copenhagen-Helsingör railway line crosses the Gentofte depression.

The second line, that of the open batteries of the north-west front, consists of three works, *i.e.*, the big batteries of Tinghöj to the south (+167), and Vangede to the north (+118), together with the small one of Budinge (+167) between them. The interval between the big batteries is 2,300 yards, while the distance from Vangede to Fort Garderhöj, which is in the exact prolongation of the line of

batteries, is 2,200 yards, which gives altogether a space of about $2\frac{1}{2}$ miles for the deployment of artillery. The positions are excellent, and in spite of the small relief, which hardly permits of their being seen from the foreground behind the advanced line of armoured forts, they command every point of the advanced terrain. The interval between Tinghöj and Husum is $1\frac{1}{4}$ miles, and likewise offers very good gun positions (heights up to 128 feet).

The glacis-like earthwork of the batteries is scarcely raised above the natural ground; the terreplein is cut out and traversed, and there are passages to bombproof accommodation and ammunition magazines. The two bigger batteries are provided each with two machine-gun cupolas for two Gatlings, to support the defence against an assault in force.

The front line of works, that of the armoured batteries of the north-west front, consists of four works on the Gladsaxe plateau from left to right, as follows:—Fort Gladsaxe (2,950 yards from the salient of the Husum defences), Fort Bagsvoerd (2,200 yards), Fort Gammelmosegard (1,750 yards), and Fort Garderhöj (2,700 yards), forming from Husum to Garderhöj an arc of 9,600 yards in length. Gladsaxe lies 2,500 yards in front of the Tinghöj battery, and Gammelmosegard 2,000 yards in front of the Vangede battery. The sites of these works, with reference to the ground immediately in front, are very favourable. The slopes of the plateau are all flat, and the differences of height not great—49 to 66 feet; infantry lines, which would be planted along the edge of the plateau, supported on the armoured batteries, would have throughout a good fire effect. With regard to the distant terrain (beyond 2,750 yards), the forts with their crests at +141, 115, 115, and 134 feet have not in every case command; there are, in fact, within two miles, dominating points as high as +121 feet. But this relation between the heights does not appear to counter-balance the advantages which the ground offers of easy movement, covered communications, and facilitated co-operation of the different parts. And these advantages are entirely on the side of the defence. The communications of the first as well as of the second line of batteries are everywhere secure on ground falling to the rear and perfectly practicable; there is ample unseen space for the concentration of troops, and for depôts and reserve artillery; on the other hand, the ground in front is divided by the chain of lakes at a very considerable distance from the position into two fields of attack, of which the southern and more important one is broken up by a number of small lakes and ponds in such a way

as very considerably to limit the facility of movement across it. The great woods which extend on the southern shore of the Füre Lake certainly improve the cover from view, which is only exceptionally given by the form of the ground, but on the other hand, they must also be considered as a disadvantage for the enemy's artillery position. There is only one part of the foreground which might become particularly dangerous to this whole defensive position, *i.e.*, the plateau of the Deer Park, which enfilades the line as well as commands it (+157 feet), and which falls gently to the rear from its greatest heights on the south; it offers flat spaces of considerable extent covered from, and not seen into by, the works of defence. But the designer, Colonel Sommerfeldt, has turned his attention to this plateau, and by including it in the line of defences has warded off any danger from it as long as Fort Fortunen, with which he has occupied the dangerous point, remains in a position to fulfil its task. This post seems, nevertheless, to be the second on which the defender should devote particular attention. We shall return later to the consideration of Fort Fortunen and the defence of the Deer Park.

The armoured batteries, or so-called forts, are of the greatest interest. At the time, some six or seven years ago, when all was confusion as to the different directions that the art of fortification was taking, when the ideas as to the separation of artillery and infantry positions, and the value of armour protection, were much less developed than of late, the patriotism of Danish ladies created a fund to make possible the strengthening of the capital by fortifications. The National Assembly had not sufficient resolution and unanimity to place at the disposal of the Government for the defence of its capital the means for carrying out the constructions recognized as necessary. Denmark, therefore, has to thank the patriotism of its ladies, who collected a sum of nearly £73,500 by voluntary contributions. With this it was possible to put in hand the construction, and when later the legislators were unable to agree as to a budget, the Government provided the means for continuing the work on its own responsibility.

The first fort, which was constructed entirely by the money collected by the Danish ladies, was Fort Garderhöj. Colonel Sommerfeldt had the difficult task of creating something entirely new; there were no types based on previous experiments; on the other hand, he was hampered by no precedents, variety of opinion or antiquated views of previous authorities. The chief difficulty with which the engineer

had to reckon, and by no means an easy one to overcome, was to make the works correspond with the requirements and views of the artillery. For the rest he was able to carry out his project as the product of his own uninfluenced decisions, and during the progress of the work he learnt himself to recognize its defects, and sought for more practical and suitable ideas; he did not adhere rigidly to the first design, but in the works subsequently constructed in rapid succession he devised new types essentially different in character.

Fort Garderhöj forms a particularly important point; it has to sweep the inundations to east and west, and at the same time covers the inlet to the southern inundation basins; to the north-west it commands the railway and road to Helsingör, which pass over the narrow Lyngby ridge. It has, further, the important task, in combination with Forts Gammelmosegard and Fortunen, of opposing the enemy's batteries. These hostile batteries have ample space for the development of their action in the extensive terrain to the east of the Füre Lake. In consequence of the manifold duties of Fort Garderhöj, it has been given a considerable and varied armament. It must be due to the influence of artillery requirements that we find here a regular sample room of calibres, constructions, and types of cupolas, viz., a Gruson armoured cupola for two long 15-cm. (6-inch), two Gruson armoured short 15-cm. (6-inch), two French 7·5-cm. (3-inch) in disappearing turrets, two English disappearing machine and two Gruson disappearing 53-mm. (2·1-inch) guns, and two observatories of Danish construction; altogether 11 armoured constructions, with four heavy, two medium, and four machine guns.

Sommerfeldt adopted from the first the principle of treating the works of the first line as armoured batteries secure from assault; he, therefore, provides no open rampart either for infantry or artillery, but a big mass of concrete from which the armoured cupolas alone project, and which have casemated gorges; the revetments slope gently to ditches on flanks and front, the ditches being flanked by caponiers. The body of the work, and, following its shape, also the ditches of Garderhöj, form a trapezium. As the engineer wished to avoid every high projection visible from a distance, the armoured cupolas had to be kept only just above the edge of the glacis, and the whole masonry construction sunk to a depth of about 33 feet. The outer edges of this great excavation, which form the counterscarps, were revetted on the front and flanks, and provided with a covered way, but the counterscarps of the gorge were, on the other hand, wisely left as earth slopes, on account of their

liability to destruction ; a high iron railing of a Prussian pattern stands at the foot of the slope, and, in combination with a thick-set hedge, gives security against assault. A postern, in prolongation of the gorge ditch, leads from the right flank down to the ditch, and is fired along from the caponier which projects from the gorge casemates ; this caponier is armed with two machine guns on the left, and with one machine gun, and one 53-mm. (2·1-inch) Q.F. gun on the right. Behind the counterscarp of the front line there is a barrack of the usual arrangement, with a corridor towards the enemy, and casemates perpendicular to it sunk to a depth of about 16½ feet, and entered from the bottom of the ditch ; at the shoulders are two reverse caponiers with a peculiar arrangement of two storeys for musketry and Q.F. guns, and for machine guns respectively. Behind the counterscarp of the right flank there are two blocks of latrines, which can only be reached from the bottom of the ditch—a not altogether desirable arrangement.

A postern, closed by an outer and inner sheet-iron door, as well as by an open iron gate between them, gives access near the gorge caponier to the interior of the work, that is, to the principal corridor, parallel to the gorge. In the rear of the corridor are the doors to the gorge casemates and to the steps leading to the turrets above them ; in the centre the cupola for two long 15-cm. (6-inch) guns, and at each end one of the 53-mm. (2·1-inch) guns. To the front there is access to the ammunition and store-rooms, as well as to an upper corridor, which connects the passages to the four turrets of the front line ; in the centre the two short 15-cm. (6-inch), and on each wing one 7·5-cm. (3-inch). Between the cupolas lie expense ammunition stores, niches for ventilators, etc. By this arrangement the four guns are satisfactorily united into one battery, and the fire direction much facilitated. The observatories are reached by the same corridors ; the machine guns on both shoulders are pushed further to the front, so that they sweep the front and flank faces, and at the same time cover the glacis and covered way, and, together with the guns of the reverse caponiers and the 53-mm. (2·1-inch) guns, which also sweep the flat slopes of the interior, give, by their very powerful fire, security against assault.

It may be added that the long 15-cm. (6-inch) gun turret lies lower than the cupolas of the front battery, and is thus entirely withdrawn from view from the front. A powerful fire effect upon the intervals could be obtained from both the 53-mm. (2·1-inch) turrets by levelling the projecting glacis filling to the rear of the flanks.

Colonel Sommerfeldt has considerably deviated from this first design in his other works. He has adopted a triangular instead of a trapezium shape, and thereby much facilitated flanking arrangements. He has somewhat decreased the depth of the excavations, and made them broader and flatter by omitting the counterscarp revetments, so that the effect of shells bursting in the ditches would be much less dangerous. He has, further, concentrated all the cupolas in a single battery.

The biggest of the other forts is Gammelmosegard (or Lyngby), with 10 cupolas; they are so arranged in a line bent slightly outwards that on the capital there is one short 15-cm. (6-inch) Gruson cupola, with a machine-gun turret in front of it, and on either side the following:—One short 15-cm. (6-inch) cupola, one French turret for two long 15-cm. (6-inch) guns, one 7·5-cm. (3-inch) turret, and one observatory; altogether four long 15-cm. (6-inch), three short 15-cm. (6-inch), two 7·5-cm. (3-inch), and one machine guns. The two forts Gladsaxe and Bagsvoerd, which were last built, and are not yet completely armed, have in the same way on each side of the capital two 12-cm. (4·7-inch) Q.F. guns in disappearing cupolas, and one observatory. Fort Fortunen has the same arrangement, but in place of the 12-cm. (4·7-inch) French gun, has 7·5-cm. (3-inch) guns in disappearing turrets.

To explain the details of these new forts, it will suffice to examine one of them somewhat more closely, for instance, Gladsaxe. This fort is so sunk in the top of the hill that the gorge overlooks the rear slope, while the highest point of the crest appears to form the summit. It is possible, in consequence of this skilful arrangement, to sweep the ground in rear from the windows of the gorge casemates while its projections see into the intervals between the forts. Expression is here given to the idea of concealed fire effect in an original and effective manner. Sommerfeldt, unlike Welitschko, does not concentrate his concealed guns in one big construction, but he forms the gorge as a flat bastion front, with two short flanks stepped one behind the other. This allows the requisite action of concealed guns as well as the flanking of the gorge. The inner flanks have two, and the outer one, gun-port; they are armed with machine and 12-cm. (4·7-inch) Q.F. guns (*Fig.* 1, *Plate* II.).

While security from assault is afforded in rear by frontal fire from the keep windows (provided with bullet-proof shutters), and by the powerful flanking fire of six guns, the flat escarp slopes which meet in a right angle in front are provided with a dwarf wall 6½ feet in

height, with a 6½ feet railing on it; they are flanked by a reverse caponier in the salient of the counterscarp. The only access to this is from the bottom of the ditch; it is occupied by infantry and artillery, and its gun-ports fire on the ditches and slopes of the main works. In addition to machine guns, two 12-cm. (4·7-inch) Q.F. guns are placed here, probably as an eventual reserve to the other guns of this nature in the work, which, therefore, contains eight in all.

The entrance to the gorge barracks is secured by an outer gate and an inner sheet-iron door; the roomy principal corridor is slightly broken to the rear and built in two storeys, of which the upper one is reached by means of two staircases and two iron ladders. The casemates are on the gorge side of this corridor. The latrines lie on either side at the end of the casemates, and can be reached also from the gorge ditch through iron doors. The expense magazines lie between the single turrets in the upper storey of the casemated blocks on the enemy's side of the principal corridor; a narrow corridor runs in front of the whole upper storey (*Fig.* 1, *Plate* II.). The entire building is arranged simply and effectively. The leading points which have been kept in view have been easy communication, convenience of fire direction, direct communication between the battery and observing stations, and convenient ammunition service.

There still remains for us to take a further cursory view of the right wing of the north-west front. This is obviously formed in the first instance by the northern inundation between Lyngby and Klampenborg, while Fort Garderhöj, Christiansholm, and the batteries in the Ordrups Krat, together with certain natural positions, serve for its defence. Close to the northern edge of the inundation basin there lie, however, the thickly-wooded slopes of the Deer Park plateau, and it is no doubt the intention of the defence to establish in time of war-preparation an advanced position on the western and northern edges of the great Deer Park. Moveable shielded mountings as well as strong abattis will find a place there. It should be noted as a wise measure of foresight on the part of the engineer that he decided to give to this advanced position a strong supporting point in Fort Fortunen, the site of which allows it to cover with fire the wide open plains to the west of the wood. The armament of the work has already been given, and the method of construction is similar to that of Gladsaxe.

The work of Christiansholm lies near the shore; it is the only one of the north-west front to which it was possible to give a broad

wet ditch. It consists of a triangular armoured work, smaller than the central construction of Gladsaxe, but similarly arranged, and furnished with three short 15-cm. (6-inch) cupolas, two machine-gun turrets, and one observing station. It is completely surrounded by its wet ditch, and is approached by a bridge over the gorge ditch, close to the gorge caponier, which is armed with two machine guns. On either side of this armoured battery, withdrawn slightly to the rear, is an open earth battery. The eastern one, called Hvidöre Battery, is a coast work, and armed with 17-cm. (40-calibre, 6·7-inch) Krupp guns. The guns are placed in pairs, with an ammunition traverse between them. Here also, as in all the land works of the left wing, the top of the traverse is not raised above the crest of the work, and it was, therefore, necessary to sink the magazine to a considerable depth. Access is by means of steps, which would no doubt be covered in in time of preparation for attack.

The following abstract shows the total number of cupolas for the defences of the right wing :—

	Cupolas for 2 long 15-cm. (6-in.).	Short 15-cm. (6-in.) Shielded.	12-cm. (4·7-in.) Disappearing.	7·5-cm. (3-in.) Disappearing.	Machine Guns.	53-mm. (2·1-in.) Disappearing.	Observatories.	Total.
Fort Gladsaxe	—	—	4	—	—	—	2	6
,, Bagsvoerd	—	—	4	—	—	—	2	6
,, Gammelmosegard	2	3	—	2	1	—	2	10
,, Garderhöj	1	2	—	2	2	2	2	11
,, Fortunen	—	—	—	4	—	—	2	6
,, Christiansholm	—	3	—	—	2	—	1	6
Tinghöj Battery	—	—	—	—	2	—	—	2
Vangede Battery	—	—	—	—	2	—	—	2
Total ...	3	8	8	8	9	2	11	49

The nature of the cupolas has already been indicated. The French 7·5-cm. (3-inch) disappearing turrets are, owing to the

great length of the gun, scarcely smaller than the 12-cm. (4·7-inch) turrets, and in general are similarly constructed with double levers and counter-weights. The machine guns in the Christiansholm turrets are Maxim guns, all the others are two-barrelled.

The defence of the left wing—the west front—was laid out by the engineer in a completely different manner to that of the right front. This may have been due not only to the peculiarities of the ground, but also to the necessity of closing this long line (over six miles from the shore of Kjöge Bay to the left flank of the Husum defences) with the greatest possible rapidity, and at the smallest cost, involving the adoption of a peculiar form of defence. The plateau of Gladsaxe forms an excellent defensive position; the armoured batteries there offer exceedingly valuable supporting points, which would also exercise great influence in the artillery duel. Fully protected by this position, the siege artillery can deploy in rear of it under favourable conditions. The flat country of the west front does not offer advantages of this nature. But here also the defence project kept to the idea that the siege artillery should be amply protected by a position in front secure from assault, and so advantage was taken of the high water-level yielded by the nature of the ground to carry a continuous line of obstacle—a long, connected wet ditch—in front of the position to be secured for the siege artillery. This obstacle naturally required defence, and such defence necessitated a communication out of sight of the enemy. A continuous line of rampart was thus naturally evolved, behind which the main road and railway were carried. The rampart had obviously to serve as a position for the safety armament as well as a defence against a strong assault, and had, therefore, to be so arranged as to secure powerful fire over the ground in front as well as over the wet ditch. The siege artillery is not, however, to be placed on this rampart; the whole position in rear of it is assigned for the action of these guns, which would only fire over it indirectly. It was possible to keep the line of rampart of a very simple form, corresponding with this idea.

The two important lines of communication—the railroad and road from Copenhagen to Röskilde—intersect the west front at about its centre. Colonel Sommerfeldt took this point as the salient, and placed here two whole or double caponiers, to the north and south, at a short distance from each other (*Fig.* 6, *Plate* II.); the line was then echelonned to the rear on both sides by breaking it up into lengths, each length ending in a half or shoulder caponier,

immediately behind which the next length commences (*Figs.* 2 and 3, *Plate* II.). With the small space to which it was possible to reduce the flanking constructions the resulting flanks are very short, and hardly recognizable from the ground in front; each caponier is able to cover with fire not only the adjoining length of ditch, but also the covered way of the length beyond. In order, however, under all circumstances to be able to cover with fire the obstacle, even independently of the working of the low caponier flanks, the engineer combined with them, in a very skilful manner, a flanking from the ramparts. Not following the ditches which pass in straight lines from caponier to caponier, he broke back the rampart above the berm on each line by two short flanks with curtains between them; with the small relief of the rampart this allowed a flanking of the ditch. But there is another arrangement which appears to be most effective. A flat ramp parallel to the line of rampart begins close behind the end of one length of it, and forms, as it were, a broad embrasure between this length and that which begins again behind it; it forms the communication to the half caponier. At the top of the ramp is an excellent position for a Q.F. gun, which can advantageously cover the ditches with fire.

There is little to add with regard to the arrangement of the rampart. Behind a 33 feet thick parapet there is in places a narrow infantry banquette; elsewhere broad, roomy banks for field guns, provided with easy ramps; and elsewhere again emplacements for the heavy guns (15-cm.—6-inch) of the safety armament. They are arranged for batteries, each of four guns, sometimes two close together. Each pair of guns have a splinter-proof traverse between them and a concrete revetted parapet in front. The pairs of emplacements are separated by very thick and long traverses, of which the tops do not come above the crest of the parapet. In the traverses are the ammunition stores for shell and cartridges, approached by steps from the road behind the rampart (*Figs.* 4 and 5, *Plate* II.). A shell-lift brings up the shells to a recess at the rear end of the traverse at the height of the way along the rampart. Recesses for ammunition are provided in all the parapet walls of the emplacements. Places for observing instruments are arranged between the batteries, and their positions trigonometrically fixed.

The wet ditch is filled by means of spring and rain water, but is also in connection with the inundations. Three sluices close behind one another, and with considerable difference of height, effect this connection. Two dams, on which run the above-mentioned railway

and road to Roskilde, serve for communication across the ditch. Foot bridges (field bridges) can, furthermore, easily be set up at the caponiers, the rampart being broken by ramps at these points. The continuous covered way widens out here and there to broad places of arms, and when the fortress is prepared for defence might be strengthened by the construction of bombproof cover.

It is open to discussion whether the defence of the west front by this line of rampart can be looked upon as complete. It would certainly be possible to give complete security to the guns of the defence by continuously guarding the obstacles and the ground in front by advanced troops and patrols. But this continuous guarding would become uncommonly difficult as soon as the enemy commenced to give play to his artillery, and any powerful attack on the long extended position which was not noticed in good time might most seriously endanger it. The necessity for being permanently ready for action, and repeated alarms, must strain and weary the troops beyond measure. It does not, therefore, appear altogether groundless to assume that the designer, who has carried out his task with so much knowledge and correct tactical perception, has here only constructed at present what was most necessary, and just as in the northern section the position was only completed by degrees, it may be taken that it is proposed ultimately to make various additions to the southern part of the defences. And, indeed, it can hardly be an error to assume that Colonel Sommerfeldt intends first to establish small shielded batteries in the foreground, to serve as powerful and scarcely vulnerable points of support to facilitate the guarding of the foreground, and render hopeless any attack by surprise ; and, secondly, to construct inside the line of defences bombproof places of arms to facilitate a rapid occupation of the position by the rifles indispensable for its defence. Perhaps we shall soon hear of the works being completed by constructions of this nature.

Examining once more the whole system of land defences *en bloc*, we find that it includes in the front line from the shore of Kjöge Bay to the Oere Sound, north of the Deer Park—an arc of 15 miles, or, measuring the individual works and intervals, a length of over 16 miles. Of this the connected lines of the left wing, as far as the salient of Husum, occupy $7\frac{1}{2}$ miles, and the right wing, defended by batteries, $8\frac{2}{3}$ miles. Where the ends abut on the sea-shore, coast batteries have been placed, of which the right, or Hvidöre Battery, has already been mentioned. The left, or Avidöre Battery, is

withdrawn behind the west front, and armed with eight 29½-cm. (11·6-inch) high-angle fire guns; the particularly flat shore here does not admit of the close approach of big vessels. Behind the front line of defence a stretch of ground 10¾ miles long is available for the action of the siege artillery.

The whole fortification is unique, and fitted to the formation of the ground in a very skilful and intelligent manner. In the south the attack must pass over well commanded flat ground, and in the north the depressions of the terrain offer very considerable difficulties to it. The idea of the tactical protection of the siege artillery by means of an outer defensive position is everywhere clearly defined, and when the anticipated strengthening of the west front and of the Husum defences has been executed, this idea will be very completely realized. On both wings a good second position in rear, protected by a very practical inundation, is available for the defence.

This can be amply prepared after the loss of the front line in such a manner as to oppose an energetic resistance against the further advance of the attack on the capital. Even a bombardment of the harbour in this case cannot be carried out with the certain expectation of a decisive result, the hostile batteries being more than 5⅔ miles distant from the same. In any event, any attack on Copenhagen from the land side would have to reckon on a very great expenditure of time. The means of subsistence of the town and of the land enclosed by the defences are certainly very considerable, especially as the possession of the whole Amager Island is assured. On this island are several coast works, which we shall deal with further on, but these, like the old walls of Christianshavn, are insufficient to prevent attempts at landing. It has, therefore, been proposed to erect some land forts on the island. Its southern portion is more than 6¾ miles distant from the centre of Copenhagen, and over 3⅔ miles in breadth. The coast throughout is nearly everywhere surrounded by shallows extending far out to sea, and these would impose great difficulties on an attempt at landing. It is only at the south-east end, at Dragör, that the edge of the channel approaches nearer to the coast, and in a former project it was intended to establish two forts at a distance of 1¾ miles from this point. They would be 5 miles away from the town. The works would have to be given considerable independence, and even then they could not by themselves prevent troops that had landed from breaking through the intervals, devastating the country, and attacking the coast defences from the rear. In order to meet troops

that had landed by a field force, and to drive them back from the coast, it seems advisable to approach the defence works nearer to the town. Co-operation with the coast battery of Karstrup would then become possible, the front towards the north would be narrowed, and the rapid concentration of the field force would be much facilitated. The excellent institution of the signal corps at the disposal of Denmark guarantees timely information of any attempt at a landing, and the natural difficulties offered by the shore are such that it would require a considerable period of time to land such a body of troops as could proceed three miles inland in the presence of a strong opposition. It appears that these considerations will eventually lead to the defences of the Island of Amager being carried considerably further to the north.

It is, of course, not possible to judge without an accurate knowledge of the proceedings what part in the provision of the land defence of Copenhagen can be claimed by Lieut.-General Ernst, Major-General Koefoed, and Colonel Tobiesen, who were on the Defence Commissions of 1872 and 1883, or what credit is due to Colonel Sommerfeldt, who superintended the work. It may, however, be assumed that the Commission laid down the tactical idea and the position of the lines to be defended, while Colonel Sommerfeldt worked out in detail the projects of defence ; the development of the types of works and their application to the ground may, therefore, be credited to him.

II.—The Coast Defences.

It has been seen that the arm of the sea which separates Seeland from Amager, to the south of the town and its harbour, is so taken up by shallows that the passage of vessels of any considerable draught is impossible. With regard to the defence of the town and harbour against attack from the sea, only the coasts of the Oere Sound, of the Konge Deep Channel, and of the east of Amager come under consideration.

For the protection of the harbour, Copenhagen formerly possessed, in addition to the citadel, the old sea defences of Trekroner, Lynetten, Mellem Fort, and Provesten, which extended for a length of 3,750 yards along the Konge Deep, none being as far as $1\frac{1}{4}$ miles from the harbour. The most important of them, Fort Trekroner, lies at the northern end of the sand-bank which stretches from the island of Amager, about 1,750 yards in advance of the most northerly

bastion of the Christianshavn defences, and forms the eastern boundary of the harbour entrance. The fort commands the harbour entrance, as well as the northern part of the Konge Deep. The capital is directed E.N.E., and the front face looks in this direction. It is formed of a row of casemates with nine gun-ports and two projections on the flanks, each return having one gun-port for flanking purposes and two firing out to sea. It faces the northern point of the Middle Ground approximately where the new fort has been built. Above the row of casemates there is an open battery with six 17-cm. (6·7-inch) shielded guns in groups of three, with a central traverse, and protected by much higher traverses on the flanks. To the rear, on the capital of the work, is the entrance of a small basin. The faces and short flanks of the fort are armed with guns between high traverses two or three together. They are mostly old Swedish 11-inch, already partially replaced by 17-cm. (6·7-inch) guns with shields—20 guns in all. The whole armament will shortly be revised for guns of this nature, and of 24-cm. (9·4-inch).

About 820 yards south of the left face of Trekroner (525 yards south of the right centre) lies the Lynetten work, on a gradually rising sand-hill; it is a big, irregularly traced battery, of which the long front face is perpendicular to the right face of Trekroner, and effectively supports the fire of that fort over the entrance to the Konge Deep. The formerly open but shallow water between Lynetten and the fortifications of Christianshavn has during the last 10 years been nearly entirely converted into a spit of land, on which docks, machinery shops and arsenals have been established. Lynetten forms, as it were, the salient of this spit, and between this point and Trekroner the water has also been obstructed by the erection of breakwaters, between which there are only passages for flat-bottomed boats, which could easily be barred.

Close to the edge of the deep water-way of the Konge Deep there follow in succession to the south the open battery of Mellem Fort (2,000 yards from Trekroner), recently armed with several 17-cm. (6·7-inch) guns, and the casemated fort of Provesten (about 3,300 yards from Trekroner), defending the southern entrance of the Konge Deep. The new harbour recently built to the north of the citadel, adjoining the shore of Seeland, should be mentioned in connection with the new sea and coast defences. At a distance of 650 yards from the citadel, a long groyne has been constructed from the shore approximately in the direction of Trekroner;

the breakwater adjoins its eastern end, and protects the entrance to the various big basins of the new harbour. Its long pile-work and stone filling bound the entrance into the old harbour. On the northern boundary of the harbour lies the first of the new defences, the battery of Kalkbranderi, between the high traverses of which are to be seen the long muzzles of apparently two 30·5-cm. (12-inch) Krupp guns. In the same way as these strengthen the left wing of the old coast defences, so the new battery of Strickers, echelonned behind Fort Provesten on the Amager coast, completes the right wing.

This girdle of works does not appear sufficient to protect the harbour and town from bombardment from the sea by new long-range guns. They, therefore, are only taken as forming an inner line against a powerful attempt to break through. A new line has been laid out at a distance of about $3\frac{3}{8}$ miles from the centre of the citadel. It consists of Charlottenlund Battery on the Oere Sound, Middle Ground Fort at the north end of the Middle Ground, and Kastrup Battery on the Amager Coast. Captain Hansen, of the Engineers, is the designer of these new, valuable and interesting works of fortification. Charlottenlund Battery is an open coast work, armed with two 35-cm. (13·7-inch) Krupps and two 17-cm. (6·7-inch) guns. Between the heavy guns there is a big traverse, containing the ammunition stores; in order to protect them from the enemy's shells, it has been considered necessary to give them about 100 feet of earth protection in front, and about 33 feet overhead. By this means, however, the battery has been made an excellent target; for at all effective distances the traverse rises clear against the park of Charlottenlund as a background. The gorge of the battery is closed, and protection from assault is secured by Q.F. guns.

The Kastrup Battery, which commands the Drogden Channel, is similar in character to Charlottenlund, but the existence of two big traverses indicate a stronger armament.

The fort at the north end of the Middle Ground forms the apex of an equilateral triangle, of which the sides are $3\frac{3}{8}$ miles in length, and the base is the line connecting Charlottenlund and the citadel. It commands the entrances to the Konge Deep and the Holländer Deep, of which the waterways can only be used by deep draught vessels approaching within 3,000 yards from the fort. An entrance to the Drogden and Holländer Deep appears more practicable from the south, where the waterway is navigable as far away as $2\frac{1}{2}$ miles from the Kastrup Battery. It has, therefore, already been under

discussion to construct a second sea fort at the southern end of the Middle Ground.

The Middle Ground Fort is an imposing construction, and deserves very considerable attention (*Figs.* 7 and 8, *Plate* II.). It is in the form of a lunette, with a flat cut off salient angle and comparatively great depth. The ramparts stand well back; but, nevertheless, the length of the faces is nearly 330, and that of the flanks about 400 feet. The angles are all rounded. In order to gain a space secure from the entrance of the sea for the foundation work in $23\frac{1}{2}$ feet of water, a breakwater was first constructed 59 feet distant from the foot of the exterior slope. In rear of the gorge the breakwater is continued by two moles disposed at right angles to each other, and a haven is formed by joining these two moles by a third parallel to the gorge. In order to obtain a space sheltered from the sea, and at the same time to confine the sand filling on which the fort is built, the breakwater was first constructed. Caissons of timber baulks closed in at the sides and bottom, and fastened together by dogs, were placed close together, filled with sand and sunk to the bottom. The outer side of the caisson away from the fort was covered with thick sheet iron, and was protected by a dam of heavy blocks of stone against the action of the sea. The upper parts of the caissons were filled in with cement concrete, and a superstructure of squared stones built on this.

A berm below the surface of the water is formed on the outer side, and on the inner a narrow patrol path, with a parapet wall 4 feet in height. On the line of the gorge of the fort a concrete quay-wall was built and joined to the breakwaters near the ends of the gorge by small lengths of wall below the water. Inside, below the top of the wall, a 9 feet depth of water was maintained, and up to this height the whole interior space between the breakwaters of the faces and flanks, as far as the quay wall and the junction walls, was filled up with loamy sand. The full depth of water was, of course, preserved in the haven.

On this bed of sand the foot of the outer slope of the ramparts was marked by a dam, sheet piling was driven in, and behind it the retaining wall was constructed. This is 3 feet above the surface of the water right round the work, and serves as revetment to the broad berm at the foot of the high bank which forms the body of the ramparts. This wall forms the escarp of the wet ditch, which is 59 feet wide, and 9 feet deep; the counterscarp is formed by the breakwater.

Of course, the fort has only exposed masonry on the gorge side, not taking into account a small supporting wall which runs right round. The centre of the work is a massive concrete construction, only exposed on the gorge front and faced there with granite blocks. Above the quay, which gives access to the harbour, is a two-storeyed central building, with big square windows, and two characteristic gateways, simple and severe in style. On either side are two single-storeyed wings, and two short projecting flanks, in which are latrines. The gateways give access to two high and broad posterns, which are at right angles to the gorge, and form the main communication to the front gallery ; at their front ends they turn slightly outwards, so as to be at right angles to the faces and to the ammunition gallery below. There are three other cross galleries behind this outer one ; the first and most roomy serves as an approach to the peace barracks, of which the casemates are in the keep at right angles to its general direction ; the floors are formed of Monier arches, and double flights of steps lead to the upper storey.

Both ends of the gallery turn outwards towards the enemy, and open on either side into the galleries under the flanks, which are in direct communication with those called above ammunition galleries, so that a complete circular gallery is formed. The second cross gallery leads to the war barracks, which are one-storeyed, with casemates parallel to them on either side ; the chambers approached from the third gallery are appropriated as stores for provisions, heating apparatus, accumulators, ventilators, and such like. Finally, the fourth gallery, which, as we have already seen, lies under the flanks and faces, serves with the adjoining chambers, lying on the side towards the enemy, for the service of ammunition, the shell-lifts, and the four flights of steps leading to the rampart. A narrow passage runs round all the ammunition stores on the outer side.

In the construction of all posterns and casemates a double arch is provided, that is, an arching of the floor as well as of the roof ; the abutments are, as a rule, so strengthened at the foot that the arch of the floor is smaller than that of the roof, and an egg-shaped section results.

The whole of this extensive catacomb construction is lighted by electricity ; ventilation is provided in a very efficient manner, all the chambers of the second and fourth galleries being furnished with ventilation outlets, and fresh air being led in through two big pipes which pass under the floors of the buildings, and open out near the level of the water.

Ascending the top of the rampart, 33 feet above the surface of the water, we find from the work which is in progress that a gun floor is formed on faces and flanks, broken up by massive, wide, and deep traverses, and that the gun banks, each told off to two guns, have a masonry revetment in rear. Traverses placed at right angles to the line of fire project above the rampart road which runs in rear of the gun banks, and are perforated by wide posterns. The steps and ammunition lifts, the latter in recesses, open on the inner side of these posterns ; the ammunition is carried to the rear of the emplacements by means of trolleys. At the blunt salient of the fort there is a single-gun emplacement for a 30-cm. (12-inch) Krupp gun of 40 calibres length. A big central traverse is placed on the capital, and contains the lifts for wounded men ; probably a light-house will be erected on it later.

The Middle Ground Fort has shields against shells, not, as may be imagined, from analogy to the new armament of the older works, but in order that the guns may be protected at least in part against splinters and shrapnel. Since the masonry and concrete works will now soon be completed, and the earthwork will at any rate be so at the commencement of the coming year, it is anticipated that it will be possible by the middle of the year, on entering the harbour of Copenhagen, to verify the strength of the armament of the Middle Ground Fort. It must be considered in the main as cut off from the new coast defences of the capital, unless the plan is reverted to of constructing another sea fort at the south end of the Middle Ground.

III.—Details of Works.

1. *Concrete Constructions.*

The bulk of the buildings consist, as might be supposed, of cement concrete. In Denmark no suggestion from abroad or explanation of the suitability of this material was necessary, for when the strengthening of the coast defences of Copenhagen was carried out in the "fifties," very exhaustive experiments were made with granite concrete ; the excellence of this as compared with every other stone material was established by firing trials, and the casemates of the sea fort of Provesten (built 1859–63) were constructed entirely of cement concrete.

The foresight of Denmark in the application of this building material for the construction of completely bombproof buildings

must be recognized, even though the Erfurt experiments may have been carried out independently in the "sixties" without knowledge of the Danish trials. At any rate, Denmark at once surpassed us* by making use from the commencement of the best materials and obtaining the fullest resisting power against fire, while we, as the result of an ill-applied economy, experimented with inferior materials, to save expense, although from the Spanish experiments we knew of the superior resistance offered by the better materials. We should have saved much expense and re-construction if we, like Denmark, had recognized at once the principle that for fortifications the best material is the cheapest. It is to be hoped that this will be a lesson for the future, and that there will be an end once for all of attempting to make use of by-products.

The proportions used vary considerably, as follows :—

	Cement.	Sand.	Stone.
1. For land defences :—			
Foundations and floors ...	1	4	7·5
Walls	1	3	6
Arches with protecting layer	1	3	6 (Broken Granite).
Roofs without protecting layer, in upper layers of 4 feet	1	2	4
In lower layers	1	3	6
2. For coast defences :—			
Generally...	1	3·5	6
The outer face of the sea wall of Middle Ground Fort	1	2	3

For the land defences all the concrete was hand-mixed ; on the other hand, in the case of the Middle Ground Fort, where it was necessary to carry out an enormous mass of work in a very confined space, mechanical mixing had to be adopted, and an English machine of a very convenient form was employed.

A mixing cylinder with a very slight inclination to the horizontal rests on a support about $7\frac{1}{2}$ feet in height. At the upper end sand

* It must be remembered that Lieut.-Colonel Frobenius is a German, and that the "us" and "we" in the following lines do not refer to English practice.—EDITOR.

is supplied on one side and stone on the other, while the cement comes from a hopper placed above the drum. The machinery, driven by a portable engine, can be so arranged as to regulate the supply of each material, so as to obtain the required proportion. The water is led into the hollow shaft of the mixing cylinder, and flows into the mixed mass in the lowest third of the cylinder's length. The concrete, which is unusually uniformly mixed, falls from the lower end of the cylinder into the trollies which run underneath it.

All the concrete-roofed buildings of the land defences, as well as the peace barracks and artillery stores of the Middle Ground Fort, were lined with hollow bricks, and made perfectly damp-proof. The remaining rooms of the Middle Ground Fort—posterns, war barracks, and store-rooms, were not lined.

2. *Roof Constructions.*

According to the available relief, the casemates were given arched roofs of cement concrete, or horizontal roofs of iron. The former were executed either as solid roofs or with protecting layers. The solid roofs, in the case of land works, were mostly given a thickness of 10 feet, but in the case of coast defence works, on account of the very considerable sand protection, it was thought that lesser thicknesses would suffice. For instance, the ammunition magazines of the Charlottenlund and Kastrup Batteries are covered with 33 feet of earth, and have frontal protection of nearly 100 feet. For protecting layers Colonel Sommerfeldt has generally made use of a packing of granite boulders instead of concrete (*Fig.* 5, *Plate* II.).

The Spanish Commissioners who visited Copenhagen in 1890, and published their report in the *Memorial de Ingenieros del Ejercito*, considered that this screen was intended to serve the purpose for which Brialmont proposed alternate layers—$3\frac{1}{4}$ feet concrete, $3\frac{1}{4}$ feet sand, 5 feet outer concrete protection. Brialmont himself threw doubts on the easy execution of this construction, because when the upper layer of concrete is laid the sand below is wetted and bound into a firm mass by the water from the cement, so that the purpose of the elastic bed of sand is partially counteracted. The Spaniards are of opinion that if the bed of sand is properly formed it acts like a bed of water, so that the blow of a projectile which has penetrated the outer layer of concrete is, possibly, carried to the masonry below with increased effect.

At any rate, the application of an outer layer of granite blocks

was tested by firing trials and found very effective. It came in very opportunely that the engineer happened to have available some big boulders, which offer a far greater resistance than broken blocks of granite. We may mention here that Colonel Sommerfeldt used throughout this packing of boulders for the protection of the foundations of walls unprotected by earth, and that it has been possible by the use of such a paving to keep them under only a thin layer of soil. An instance of this occurs in the foundations of the $6\frac{1}{2}$ feet high retaining walls which carry the palisade fence at the bottom of the ditches of the forts.

The dimensions of the roofs secure throughout great strength. For instance, the ammunition magazines of the west front have a thickness of arch of 5 feet, over which is 5 feet of sand, 6 feet of outer stone protection, and then a thin earth covering of $2\frac{1}{2}$ feet. These dimensions are to be considered as minima, and in many places are substantially increased (*Fig.* 5, *Plate* II.).

The iron roofs are supplied in two different forms of constructions; the shoulder caponiers (*Fig.* 3, *Plate* II.) have girders carried on strong, massive steel pillars with 5 feet clear span. On these rest the roof of rails or iron, either placed close together, or with intervals spanned by curved sheet iron. The concrete cover laid on this has a thickness of 10 feet, and has again over it a layer of earth of $1\frac{3}{4}$ feet to protect it against weather. The roofs of the central caponiers of the west front (*Fig.* 6, *Plate* II.) have, on account of the smaller relief available, been given smaller dimensions, and are, therefore, armoured in a special manner. The supports are stronger, the concrete cover reduced to 3 feet, but above it are armour plates about $4\frac{3}{4}$ inches thick, fixed to the concrete cover by bolts passing through its whole thickness. A layer of asphalte furnishes protection against the effect of weather. All iron roofs are given an inner close boarding of wood to guard against condensation. The buildings are perfectly dry.

3. *Flanking Arrangements.*

The armoured batteries of the north-west front, which are distinguished by the name of "forts," have, with one exception (Fort Garderhöj), the trace of a right-angle triangle. For the flanking of the ditches of the faces a single reverse caponier of the salient is, therefore, sufficient. In the case of the four-sided fort Garderhöj, two are, of course, provided. Access to the caponiers is, in every case, through the small loopholed doors opening on to the bottom of

the ditch, and is not very satisfactory, as it involves passing along the whole length of the ditch from the gorge postern.

The caponiers are, however, all provided with extensive accommodation below. The arrangement of the loopholes is peculiar and original. An upper one is always provided over the interval between two lower ones. A stage is erected about 6½ feet above the floor of the caponier, from which the third upper loophole is used by a man lying down. By this means a stronger flanking fire is obtained without increased space.

A special arrangement of the ground plan of the barracks serves for the flanking of the keep (*Fig.* 1, *Plate* II.). This plan might be termed that of a flat bastion front; on each side, however, instead of one, there are two, short flanks stepped one behind the other, each of the inner parts with two, and the outer parts with one, gun-port. The use of machine guns allows the space to be reduced to a minimum. Colonel Sommerfeldt desired to use these guns from the keep also as masked guns, and attained this end by placing them, so to speak, under the higher reverse slopes of the works. The ditches of the keep could thus be kept quite flat, and it was possible to utilize the fire from the flanking casemates of the keep for sweeping the terrain outside the fort. For this reason a 4·7-inch Q.F. gun is placed on either side as a masked gun.

The flanking of the wet ditches of the west front, which is 7½ miles long, has already been described (*Figs.* 2 and 3, *Plate* II.). In order to protect the shoulder caponiers against curved fire over the covering orillon, the three gun-ports are echelonned one behind the other, the wall being stepped in plan inside and sloped outside. In the centre is a 53-mm. (2·1-inch) Q.F. gun, and on either side a machine gun. Each gun has about 5 feet of wall space, and the mean depth of the caponier is 14½ feet; the roof being carried on strong massive steel columns, the interior space is amply sufficient. Towards the enemy a projecting orillon protects the casemate. It is formed of granite ashlar-work, and only covered by a thin layer of earth. Inside the orillon there is a latrine. To the rear of the caponier there are two doors, of which one leads out into the open, that is, to the communication ramp, while the other gives access to two small rooms which serve for dwelling purposes. Their windows, which are provided with strong iron shutters, flank the entrance to the caponier. The floor, as in all dwelling casemates, is not boarded, but covered with linoleum over a layer of concrete. The cost of such a construction amounts to £1,750.

The central caponiers (*Fig.* 6, *Plate* II.) consist practically of two demi-caponiers back to back. The dwelling-rooms are placed at the front, and not at the back end of the caponier, and are built into the covering mask, so that on the one side the latrine, and on the other side the air and light openings of these spaces lie on the reverse of the orillon. The caponier has a mean clear space between the gun-ports of $16\frac{1}{2}$ feet. A postern through the rampart closed by an open iron gate forms the approach. A small dam leads across the wet ditch.

4. *The Bridges.*

In excavating the broad wet ditches, the engineer had to carry out the work without in any way impairing the utility of the numerous communications of every description and size across the lines of defence. The construction of temporary bridges and road diversions was partly prevented by local difficulties, and would also have been very costly. Colonel Sommerfeldt, therefore, decided to construct the bridges on the spot, before the excavation of the ditches, and carried out this work with the most satisfactory results.

The supports of the bridges were formed of trestles, of which the solid steel screw-piles were chosen of different lengths and strengths, according to the proposed height of the bridge, and screwed into the ground to commence the work. Each pair was connected by girders, and provided with the bridge-covering before the excavation was commenced. According to the importance and purpose of the bridge, the covering consists of timber or iron (beams and sheet iron) and ballast. When the roadway was completely prepared for traffic the excavation below it was put in hand. When it had been carried out to half the proposed depth the diagonal and cross-bracing were added. In all of the bridges the piles of each trestle are connected together with a stiff horizontal compression bar, and the right angle formed above these braced by diagonal tension rods. In the bigger and higher bridges a similar connection was furnished between the piles of each pair of trestles.

The design and construction has stood some years' heavy wear, and may be recommended for imitation when the conditions and the soil are favourable.

5. *Other Details.*

The use of xylolith plates for the treads of steps should be noted, as they have proved completely satisfactory. Monier arches were used in certain cases, for instance, for the floors of the two-storeyed

casemates, and it may be mentioned incidentally that in the construction of the fine new harbour the platform is formed of Monier plates instead of wooden planks, as it is hoped by this means to prevent the piles being hollowed out by the boring insect. Finally, an arrangement of the casemates of the armoured batteries may be mentioned as worthy of imitation (*Fig.* 1, *Plate* II.). Behind the one-storeyed dwelling casemates in the gorge there runs a two-storeyed corridor, of which the upper storey contains the entrances to the armoured cupolas placed in the battery. In order to allow the dwelling casemates to have the advantage of the electric lighting of this upper corridor when the steel window shutters are closed, the crown of the arching of the casemates is placed about $1\frac{1}{2}$ feet above the floor of the corridor. The casemates are lighted through the windows formed in these segments.

IV.—Cost of the Land Defences.

It is obviously only possible to report the cost of the land works, since the Middle Ground Fort, the key-stone of the coast defences, is not yet finished, but it may be already predicted that the total cost of land and coast defences will not exceed £1,500,000. It is possible that, including all provision for artillery, it may amount to £1,675,000.

It is certainly astonishing with what small means Colonel Sommerfeldt has succeeded in carrying out his task. On the other hand, the necessity for economy is easily accounted for by the difficulties which the Ministry had to encounter in the obstinate refusal of the National Assembly to vote money, and in the want of confidence on the part of the population. Including all cupolas and the complete armament, with ammunition, the defensive position, 16 miles in length, except only the coast batteries, has been fortified for the fabulously small sum of £762,500, that is, about £47,656 per mile, including the cost of land, and about £39,433 per mile exclusive of this cost.

The $7\frac{1}{2}$ miles of front on the left wing required about a half of the whole sum, that is to say, £370,450, or about £49,393 per mile, including cost of land, or £37,904 excluding this cost. The line of rampart which, with its extensions to the flanks, here forms the defences just falls short of $8\frac{3}{8}$ miles. Acquisition of sites cost about £87,500, the armament about £27,450, so that there remained for the engineer works the sum of £255,500, that is, £29,483 per

mile. This is certainly an extraordinarily small sum, taking into account that the excavation of the ditches had to be executed for the most part under heavy water pressure ; that, further, a great part of it (78,360 cubic yards out of a total of 3,265,000) was in hard rock ; and that, finally, the construction of $8\frac{2}{3}$ miles of high road and $6\frac{1}{4}$ miles of railway of normal gauge is included in this sum. The road constructions required £22,120, the bridges and dams £14,728, the earthwork £136,534, the masonry (49,890 cubic yards) £58,128. Each demi-caponier cost about £1,750. The expenses for contingencies and administration—about £25,000—are comparatively high, which may be explained by the fact that with the small establishment of Engineer officers a great number of civil employés (at times 60) had to be appointed in order to complete the work in the short space of eight years.

The information available with reference to the defences of the right wing is still more instructive and interesting, for the armoured constructions are here the first consideration, and an attempt may be made to compare them with Brialmont's armoured constructions for the Maas defences.

The expenditure incurred has been :—

	Including Acquisition of Land.	Excluding Acquisition of Land.
	£	£
For the Inundation and its Batteries and Christiansholm	121,632	95,732
For the Batteries of the 2nd Line...	21,896	19,864
For the Armoured Batteries of the 1st Line	236,824	228,312
Total	380,352	343,908

Taking the length of the line as $8\frac{2}{3}$ miles, the costs work out to £43,887 and £39,682 respectively.

It will be noticed that the addition of the two sums for the left and right wings fell short of the total of £762,500. The balance of about £11,698 was expended in gun-sheds and in quarters for those superintending the work, contingencies which have not been included in the above.

The expenditure for the forts is made up as follows :—

Forts.	Acquisition of Site.	Earthwork.		Masonry.		Road Constructions.	Administration.	Total for Works.	Shields, Guns, and Ammunition.	Total Cost.	
		Quantities.	Cost.	Quantities.	Cost.	Cost.				Including Acquisition of Site.	Excluding Acquisition of Site.
	£	Cub. yds.	£	Cub. yds.	£	£	£	£	£	£	£
Garderhöj	1,736	109,704	4,256	24,161	22,232	168	3,808	30,464	33,432	65,632	63,896
Gammelmosegard ...	1,736	84,890	2,520	23,769	23,128	168	2,016	27,832	35,224	64,792	63,056
Three Small Forts ...	5,040	104,480	4,368	34,347	41,104	840	7,504	53,816	47,544	106,400	101,360
Total	8,512	299,074	11,144	82,277	86,464	1,176	13,328	112,112	116,200	236,824	228,312

The cost of the cupolas, guns and ammunition thus amounts to about a half of the total expenditure ; in the small forts it is 44 per cent., at Garderhöj 52 per cent., and Gammelmosegard 56 per cent.

The five forts together occupy a front from Gladsaxe to Fortunen of close on 9,020 yards. One may assume that, in accordance with Brialmont's principles, as exhibited in the Maas defences, three forts would have been considered sufficient, *i.e.*, two of his bigger type on the Gladsaxe and Fortunen sites, and one small one between them ; the interval would have been rather over $2\frac{1}{2}$ miles. It will be of interest to compare the artillery effects and the costs of the two systems of defence.

One of Brialmont's big forts (according to R. Wagner's *Armoured Defences from the Point of View of Economy*) is armed with two long 15-cm. (6-inch) guns, four 12-cm. (4·7-inch) guns, two 21-cm. (8·3-inch) howitzers, and four 57-mm. (2·2-inch or 6-pr.) Q.F. guns, or altogether 12 pieces in cupolas for fire outside the works, in addition to nine to twelve 57-mm. (2·2-inch or 6-pr.) Q.F. guns for the defence of the ditches. A small fort is armed with two long 15-cm. (6-inch) guns, two 12-cm. (4·7-inch) guns, one 21-cm. (8·3-inch) howitzer, and three or four 57-mm. (6-pr.) Q.F. guns, or altogether eight to nine pieces in cupolas for fire outside the work, in addition to seven to nine 57-mm. (6-pr.) Q.F. guns for the defence of the ditches. This results in the following comparison between the armaments of the two big and one small Brialmont forts and of the Copenhagen works to which they correspond :—

	Three Brialmont Forts.	Five Copenhagen Forts.
Long 15-cm. (6-inch) guns	6	6
Short ,, ,, ,, ...	—	—
,, 21-cm. (8·3-inch) howitzers	5	—
,, 12-cm. (4·7-inch) guns...	10	—
,, 57-mm. (6-pr.) Q.F. guns	11	—
,, 12-cm. (4·7-inch) Q.F. guns	—	8
,, 7·5-cm. (3-inch) Q.F. guns	—	8
,, 53-mm. (2·1-inch) Q.F. guns	—	2
Machine Guns	—	2
Total	32	32

The fact that the three Brialmont forts only require 30, while the five Copenhagen forts take 50 guns for the defence of the ditches, does not affect the case as far as fire outside the work is concerned ; on the other hand, the masked action of the gorge guns for firing to the flanks does affect the case ; of these masked guns (4·7-inch Q.F.) the Copenhagen forts have four, two in position and two in reserve.

The general fire effect to the front may be taken as approximately equal in both cases, but the division of the same number of guns into five instead of three batteries seems possibly to be the more favourable. I do not, however, belong to those critics who advocate arranging the cupolas of defences by single emplacements, in order to present smaller targets to the enemy. The idea of the accuracy of artillery fire is very much exaggerated, and at the present time more than ever, so that all considerations of fire direction and concentrated action of guns are sacrificed in order to obtain security by the disposition of guns, so that they may be safe against one single unerring shot of the attack. The fact is ignored that it requires an enormous expenditure of ammunition in order to damage a cupola even on the ranges, and it seems to be considered necessary to hide it when actually applied, as if it could be broken like the shell of an egg. Unnecessary extension of target, which might result from massing together the cupolas, can be very well avoided, but the juxtaposition of some of them in batteries, in order to secure good fire effects as required by the old principles, not yet contraverted, does not come under this head. The first question should be always the fire effect of the gun, and the consideration of its protection against hostile fire comes afterwards ; it is not *vice versâ*, as some seem to think.

It is just in this concentration of shielded guns in batteries, as carried out by Colonel Sommerfeldt in his small forts and in Gammelmosegard, that he appears to me to have attained a happy medium. Every considerable depth of target is avoided by grouping on a slightly curved line ; the fire direction is much facilitated by the arrangement of a common passage, without in any way sacrificing the action towards the flanks. This action is very powerfully supported by that of the eight masked guns, so that the flanking effect from the Copenhagen forts can be favourably compared with that from the Brialmont forts. The fire effect towards the gorge side is, however, greater, for Sommerfeldt can turn all his cupolas to the rear (with the exception of one machine-gun tower at Gammelmosegard and two at Garderhöj) without their interfering with each other, while Brialmont can only fire to the rear with five out of

eight guns, a total of 21 against 29 in the Copenhagen forts. This advantage also results from the arrangement of the cupolas on the front of a battery.

By taking the five Copenhagen forts to be only equal, as regards fire effect, to the three Brialmont works, we can compare the cost of the two systems, as far as the varying local conditions permit. Generally, the cost of construction, exclusive of the acquisition of the sites, of the Copenhagen forts comes to £112,112, that of guns and cupolas to £116,200 ; against this the average price, according to Wagner, of the Luttich forts amounts to $2 \times £90,680 + £61,600 = £242,960$ for the construction of two big forts and one small one ; the cupolas for the same come to £130,400. The slight difference in the cost of the cupolas allows us to omit these from consideration, and confine ourselves to the cost of construction. The enormous difference under this head is striking. The five Copenhagen forts have only cost the half of the three Belgian works. The first cause of this difference which suggests itself is the lower prices in Copenhagen, which undoubtedly obtain as regards earthwork ($7\frac{3}{4}$d. against 2s. 7d.), but, on the other hand, the masonry is dearer (£1 5s. 11d. against £1 1s. $4\frac{1}{2}$d.), as well as the manual labour in mixing concrete ; by taking the Luttich prices, the cost of construction of the Copenhagen forts comes to a still smaller amount, namely, £102,608.

Let us, however, compare the masses of earthwork and masonry.

	Earthwork, cub. yds.	Masonry, cub. yds.
Five Copenhagen forts ...	299,074	82,278
Three Luttich forts... ...	562,886	210,527

The bulk of the earthwork is double, and of the masonry treble, in the latter case. Taking into consideration the different prices, the earthwork costs about five times as much, and the masonry about double.

The main reason for the difference is, therefore, the considerably greater extension of the Brialmont forts, necessitated first by the combination of the artillery with the infantry defence, and then by the method of grouping the cupolas, which involves a considerable extension of the sub-structures, corridors, passages, and ammunition spaces, so that the big mass of concrete which forms the centre of the work is of considerably greater extent. The complete revetment of the counterscarp in the forts of the Maas defences, which does not obtain

in those of Copenhagen, also affects the result. It can hardly be maintained that the value of the latter, as regards freedom from assault, is essentially diminished, for this is maintained principally by the powerfully defended obstacle at the bottom of the ditch, and a good fire defence of the gorge. In both respects Colonel Sommerfeldt's forts are the best and safest. The one doubtful point lies in the reverse caponiers, which are wanting in a covered communication with the interior of the fort, and to which the only access is across the bottom of the ditch. The garrisons of these caponiers are, therefore, completely isolated for long periods of time, as the ditches will be continually exposed to shells and splinters during the bombardment; these garrisons will, therefore, be called upon to make a high exhibition of their military virtues.

The complete separation of the infantry from the positions of the shielded guns, as well as the separation of the latter into small batteries with slight depth, appears to me to be altogether an advantage in comparison with the Brialmont forts, though it must not be overlooked that the purposes of the two systems are essentially different. Colonel Sommerfeldt has also proved that though it is not possible to reduce the cost of the cupolas, yet by a skilful arrangement the expenditure on the batteries containing them can be considerably lessened.

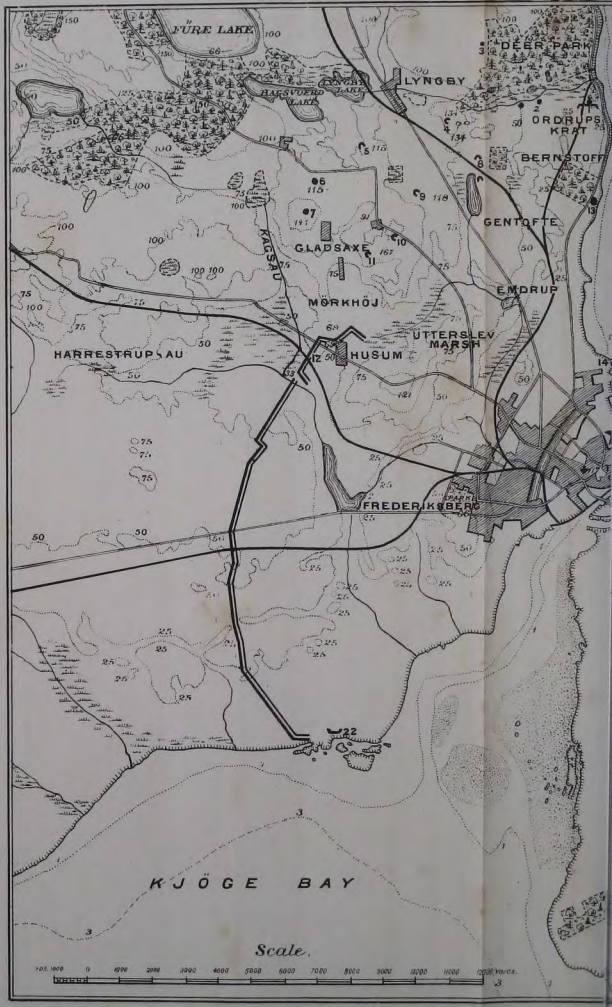
Looking again at the figures given by Lieutenant-Colonel Wagner, we find that the front of the Copenhagen defences with which we have dealt would have cost, without cupolas but with the same armament, £442,800, and according to the type of the Maas defences, with cupolas, £373,400, against the actual cost, with the same cupolas, of £228,312. The application of the costly cupolas has, therefore, resulted here in the reduction of the cost to about a half.

I have left completely on one side the consideration of the second line of batteries, for these only correspond to the prepared supporting positions of the moveable defence artillery of our fortresses; the reserve guns will find excellent employment in this partially prepared position; movable shielded guns will be used together with infantry in the intervals of the line of forts.

As we have seen, Copenhagen has not been given new enceinte walls since the old ones, which even in 1807 were not in a position to protect the town from bombardment and capitulation, were demolished and converted into a zone of delightful gardens and parks. It was in order to give the necessary protection against

bombardment that the far advanced lines of land and sea defences were adopted. This is the principal danger against which the invaluable material of the fleet, the rich sources of supply of the capital, and the harbour, with its various technical establishments, have to be guarded against. For there is less to fear from such a political combination as would expose Copenhagen to a long and regular siege than from a *coup-de-main*, an attempt by a sudden onslaught to take possession of the harbour, which the neutral State would not willingly place at the disposal of one of the European belligerents, but which it might be of the greatest importance to such a belligerent to possess. Against such an undertaking the new land and sea defences present an insurmountable barrier; an enceinte is not needed.

Nature itself has, however, offered a substitute for a closed enceinte by making it easy to produce a continuous protection. The inundation offers the means of producing a strong front obstacle which, without requiring much work, allows of an obstinate defence. It is to be hoped that the defenders of Copenhagen may never be forced to make use of it, and that the strong armament which Colonel Sommerfeldt and Captain Hansen have mounted may always suffice to ward off any attempt at attack. If such an attack never takes place, the defences will have best fulfilled their purposes, and the million and a-half sterling will have been laid out with good results. In times of long peace, military expenditure for war should not be avoided as unnecessary. It saves, in time of war, damage to men and property which might be past all healing if this expenditure had not been incurred. But care must be taken that the defences do not become obsolete and useless. Denmark has taken her precautions in time.


FURE LAKE
HARSVORD LAKE
LYNGBY
DEER PARK
ORDRUPS KRAT
BERNSTOFF
GENTOFTE
GLADSAXE
KAGSAU
EMDRUP
MORKHOJ
UTTERSLEV MARSH
HARRESTRUPSAU
HUSUM
FREDERIKSBERG
KJÖGE BAY
Scale.

)F COPENHAGEN.

PLATE I.

REFERENCE.

1. *Christiansholm & Hvidöre Battery.*
2. *Batteries in Ordrups-Krat.*
3. *Fort Fortunen.*
4. " *Garderhöj.*
5. " *Gammelmosegard.*
6. " *Bagsvoerd.*
7. " *Gladsaxe.*
8. *Batteries South of Bernstorff.*
9. *Vangede Battery.*
10. *Budinge* "
11. *Tinghöj* "
12. *Husum Defences.*
13. *Charlottenlund Coast Battery.*
14. *Kalkbranderi* " "
15. *Fort Trekroner.*
16. " *Lyretten.*
17. " *Mellem.*
18. " *Provesten.*
19. *Strickers Coast Battery.*
20. *Kastrup* " "
21. *Middle Ground Fort.*
22. *Avidöre Coast Battery.*

Note.

The heights are given in feet, and the soundings are shown by fathom lines.