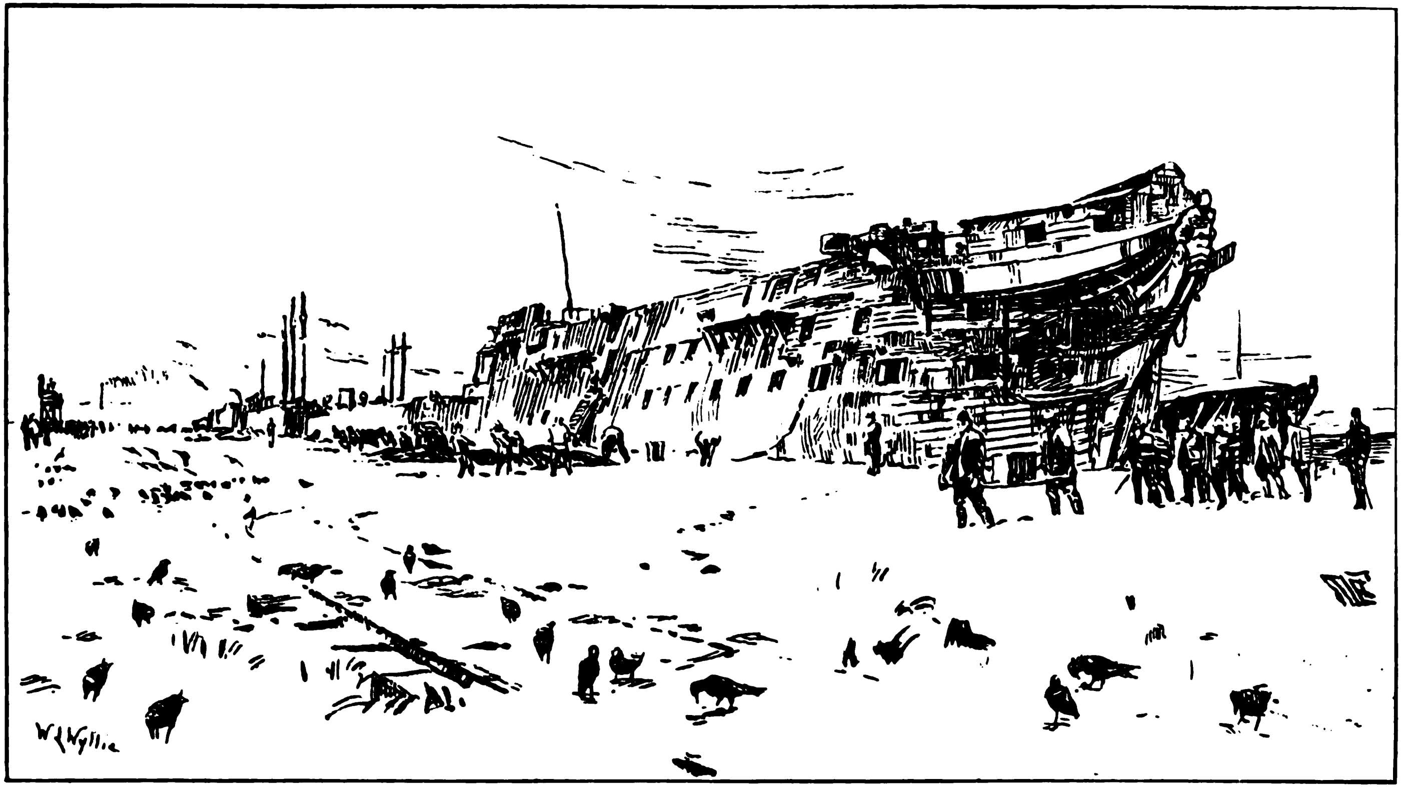

The Last of H.M.S. "Hood."

From a pen-and-ink sketch by W. L. Wyllie, Esq., R.A.

HISTORY

OF

SUBMARINE MINING

IN THE

BRITISH ARMY.

BY

LIEUT.-COLONEL W. BAKER BROWN, R.E.

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PREFACE.

WHEN first asked by the Committee of the R.E. Institute to undertake a record of the work of the Submarine Mining Service, I fully realized that the task was a heavy one, but the honour was too great to make a refusal possible.

Carried out as it has been in the intervals of four years of strenuous work at the War Office, the task has proved to be full of interest, but even more engrossing than I had anticipated, and I can only plead the superior claims of my military duties if I have in places failed to adequately describe some phase of development or have passed too lightly over the services of individuals.

Of material for the history there was more than enough. A circular addressed to all surviving officers of the rank of Captain and upwards elicited replies from the great majority, while many officers of the S.M. Militia and Volunteers also sent contributions.

Thanks are also specially due to Miss Tyler, who compiled from the original diaries the account of Colonel Pasley's early operations, also to Major W. P. Brett, who kindly contributed the account of Submarine Mining in India, and to Lieut.-Colonel Parnell, who collected most of the information about Australia.

Among other officers who assisted materially were Colonels Malcolm and Bucknill, Sir C. Watson, H. E. Rawson, Penrose, Boyce, Middlemass, Mills, Carr, Dumbleton, and many others.

Much detailed information has been obtained from the official Army lists and from the *R.E. Journal*—which is a mine of information on all Corps history—while Edwards' *List of Officers of the Corps* proved a most valuable book of reference.

It is usually assumed that War Office records are always available, but in practice all papers undergo a strict process of "weeding," and only those which are particularly important are retained. Special thanks are therefore due to Major J. H. Bailey, of the War Office, for the almost uncanny prescience with which he has succeeded in retaining in existence papers and documents which proved most valuable for reference, including many early drafts by Sir W. Jervois, Colonel Nugent, and others, and the early practice reports of 1872! Major W. G. C. Browne, of the Adjutant-General's Branch, contributed the list of trained officers on which Appendix II. has been based.

Major-General R. M. Ruck added to his many labours for the good of the service the task of looking through my first drafts, while Brig.-General Rainsford-Hannay undertook to obtain the necessary official permission to use reports and papers.

In conclusion, may I expressly apologize to those officers who served the Submarine Mining Service faithfully and long, but who, not having the good fortune to reach the higher appointments, may find in these pages only scant reference to their labours.

The success of the Service depended not only on the work of the individuals at the head, but also on the average excellence attained by all ranks.

Both General Sir R. Harrison and Major-General R. M. Ruck have kindly consented to write "forewords" to this History.

The former as I.G.F. at the time when Submarine Mining had reached its zenith, is well qualified to speak of its value in the general scheme of defence, whilst General Ruck's close association with Submarine Mining is clearly set out in the following History.

W. Baker Brown.

INTRODUCTION.

FROM the earliest times of which we have any record, it has been the business of Military Engineers not only to manipulate the engines of war, but also to endeavour to improve and supplement them. Students of history will realize how it was the art of the Engineer that enabled the armies of civilized nations to beat back all attacks of barbarism, no matter how fiercely delivered, or how, in conflict between civilized Powers, victory was usually won by the people who paid most attention to the equipment and training of their soldiers.

The Military Engineers of the British Empire have not been behind those of other nations in watching the progress of science, and endeavouring, as far as the funds placed at their disposal allowed, to make improvements in war appliances.

The story of one of these improvements—how it developed, and how, when it had arrived at a condition of considerable efficiency, it was handed over by its originators to another branch of the Nation's service—is told in the following pages.

The improvement in question was an adaptation of a system of defence by land mines to the peculiar needs of a fortress bordering on the sea. The difficulties of such an adaptation consisted in its being necessary to lay mines in a sea channel at very short notice, and very rapidly, under the condition that the mines so laid (either for practice in time of peace or as a permanent defence in time of war) did not endanger the passage of friendly ships.

The means used for effecting what was required was electricity. Both the electric cables for purposes of firing and communication, as well as the mines themselves, had to be laid with exceeding care and skill. Elaborate position-finders had to be fixed to mark the position of ships, and electric lights had to be provided to enable the defence to be worked by night as well as by day. To do all this, practical, as well as theoretical, knowledge was essential. Careful organization also was required, so that the necessary skilled *personnel* should always be ready at every defended port.

The first time that I appreciated the work that was being done by the Royal Engineers in regard to submarine mining was when I commanded the Western District of England in 1890–95. At that time the District was directly under the War Office. It comprised the fortresses of Plymouth, Falmouth, Milford Haven, and the Severn. At each of these places there was a submarine mining centre. Each centre was a school, and at the same time the nucleus of defence in time of war. At Plymouth and Milford Haven, which were Naval stations as well as fortresses, there were a few Regular officers and men acting as instructors and storekeepers. A Militia Corps, which came to the station annually for training, formed the war garrison. At Falmouth and the Severn there were fewer Regulars; and the garrison consisted mainly of Volunteers.

The whole business was worked, under the Inspector-General of Fortifications at Headquarters, by a special Inspector.

When I was in the Western District, Sir Robert Grant was Inspector-General of Fortifications, and, in order to ensure the closest touch with the Royal Navy, he instituted the arrangement of a Naval adviser in his office, whose special duty it was to deal with all questions relating to the defence of Naval ports and coaling stations.

The military inspection of Submarine Miners was under the General of the District, assisted by the Commanding Royal Engineer. In making my inspections, which often were done at uncertain times, I invariably found the whole local business going like clockwork. Now and then there were difficulties owing to shortness of funds to provide the necessary stores and buildings. But it was recognized that everything could not be done at once, and the rule was that, as far as possible, war conditions should be able to be taken up at any moment.

While on this subject of readiness for war I may mention that not only I myself, but all Naval officers whom I came across who had any knowledge of the submarine mining arrangements under the Royal Engineers were open-mouthed in its praise. They used to say "Why, it is just like the Royal Navy!"

Before finishing these few remarks perhaps I ought to say that, while I was in command at Devonport, and also some years afterwards when I became Inspector-General of Fortifications, I found that the Submarine Mining Branch of the Royal Engineers worked in entire harmony with the Naval authorities at the Admiralty. The appreciation of the work done, and the desire that was known to exist to subordinate everything to Naval requirements, was further accentuated by the appointment I have above alluded to of specially selected Naval officers as advisers to the Military Fortification Branch. I had the good fortune to make acquaintance with several of these officers while I was in office, and through them with others of higher rank. In discussions with Naval officers of eminence I often raised the question of submarine mining and its command, and my impression is that all I spoke to were of opinion that, the *rôle* of the Navy of Great Britain being an active defence, no Naval vessels should be tied to the shore. Consequently the best policy to pursue, as long as the then existing cordial relations were maintained between the Services, was to leave the sedentary defence of sea as well as land fortresses in the hands of the Army.

RICHARD HARRISON.

Some three to four years ago the Council of the Royal Engineers Institute approved of a proposal that a history of British Submarine Mining should be written, and Major (now Lieut.-Colonel) Baker Brown, R.E., kindly undertook to perform this onerous work, amidst, as he states, the duties of a very strenuous appointment at the War Office.

The volume before me shows how very thoroughly and how very ably he has redeemed his promise, and I am sure that the Corps, especially the ex-Submarine Miners, will greatly appreciate the results of his labour.

I have been asked by the Council to make a few introductory remarks, and I find this task somewhat difficult owing to the circumstances under which this very efficient service was terminated.

As I feel that the time has scarcely yet arrived when this subject can be fully discussed, I prefer to dwell upon the memories associated with a service which combined such varied interests with a highly efficient military organization and the best possible spirit ; a service which anticipated many of the conditions of the new Territorial Force by some 20 years, which for the first time united the Regulars and Auxiliary Forces in one working unit, and which gave rise to much, if not most, of the recent scientific impulse in electrical and mechanical methods as applied to military purposes.

As indicated by the record of services in this volume, the happy mixture of scientific and practical work, the close interworking of all ranks, the individual responsibility, and the quick decision appertaining to water work, and also the experience acquired in dealing with large parties of men, proved a fit training for almost any description of duty in the after career of the officers ; such training will be difficult to replace.

The happiest recollection of the old Submarine Miner is, I am sure, the comradeship which prevailed in all ranks and the invaluable support which the officers received from those serving under them. This was an inheritance which was transmitted from the earliest days, in fact, it is difficult to adequately describe the enthusiasm and *esprit de corps* of the early Submarine Miners, without which probably nothing much could have been achieved.

I commend this sentiment and much also of this history to the attention of our future aeronauts as the lines to follow in order to attain the rapid development of a new service.

There is one more feature of the service which is I think deserving of special attention. It was essentially not a "one man's show." The results obtained could only have been achieved by many men working hand in hand for the general benefit. As Colonel Baker Brown so aptly says in his preface, "The success of the Service depended not only on the work of the individuals at the head, but also on the average excellence attained by all ranks," and I fear that there are many instances (complete though the history is) where credit should have been given in greater proportion to the less highly graded individuals.

This work of Colonel Baker Brown's will furnish one more chapter in the general history of the Corps of Royal Engineers, illustrating the extraordinary diversity of the duties which fall to the lot of the Corps as pioneers of the Military Service.

It is a chapter which the Corps may be justly proud of.

R. M. RUCK.

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CHAPTER I.

INTRODUCTORY. — GENERAL DEVELOPMENT OF MINING.— HISTORICAL.—1ST PERIOD—1863–1870.—EARLY BEGINNINGS.

THE history of Submarine Mining in the British Army is of interest both to the military student and the general reader, as the period of its existence—1863 to 1905—coincides with much of the modern development of the art of war both afloat and ashore.

The Submarine Mining Service was remarkable for the cheapness and efficiency of its organization and its success in enlisting the services of a body of auxiliary corps drawn from many nationalities and under many conditions of service.

In the course of its career it met and overcame much criticism and opposition, and at the time of its suppression it was probably the most efficient service in the whole of the British Army.

The system of submarine mining defence adopted was an integral part of the fortress defences of our ports, and was as much a part and parcel of these defences as are the various obstacles placed immediately in front of land forts or any entrenched position.

In fact it is not too much to assert that they constituted the essential obstacle defences, without which no fortified position constructed against land or sea attack can be termed thoroughly efficient.

Before commencing the detailed investigation it is proposed to begin this chapter by a short explanation of the nature of mines, and then to give a general summary of the development of submarine mining as a whole, which will provide a framework on to which the details of the 42 years' work by the British Army can be built.

It must be noted that prior to 1870 all forms of explosive apparatus for use in the water were classed as "torpedoes," and that it was not till about that date that they were definitely divided into two classes —the "torpedo" and the "submarine mine."

The first is capable of motion through the water, whether connected to a boat by a spar or tow line, automobile as the Whitehead, or partly automobile as the Brennan. The "mine," on the other hand, is, when laid, usually moored in position, except in the form of drifting mines, which move with the water, not through it.

It is also necessary to explain that mines themselves are now grouped into two classes, controllable or non-controllable, or, as they are often classified, "electrical" or "mechanical."

In the first class the method of firing is entirely by electricity, the source of the electrical power, whether battery or dynamo, being contained in a station on shore, and connected to the mines by insulated cables. By simply disconnecting the supply of electricity, a process as simple as switching off the electric light in a room, this class of mine is made inert, and as far as its explosive effect is concerned, entirely harmless.

In the second class the method of firing is contained in the mine itself; it may derive its power from a small electric battery, or from a pistol, spring, or suspended weight. The important distinction is that once laid it remains in a dangerous condition for a definite time, during which time it will explode if hit with sufficient force by any vessel. Safety arrangements are introduced to ensure that the firing arrangements do not come into action during the laying of the mine, and also in some cases to make the mine inactive after a definite period of time; but the best method of ensuring this has taxed the ingenuity of many of the greatest inventors, and no method has been devised which gives certainty of success.

In addition to the above broad classification, the first class, or electrical mines, are capable of further subdivision into two classes, according to whether they are fired by "observation" or "circuit closer."

The "observation" system depends on two careful observations made by an operator on shore, one of the exact position in which mines are laid, the other of the track of hostile ships passing over the minefield. When the ship is seen to be passing over a mine, the corresponding switch on shore is closed and the mine fired. To allow for errors of observation such mines are usually fitted with comparatively large charges of explosive and laid under a considerable head of water (30′ to 60′) to develop their best explosive effect. They can thus be arranged so as to be always well below the bottom of any friendly vessels using the port, and, except that anchorage in the minefield itself must necessarily be forbidden, such mines offer no obstruction to the free use of a port by our own ships.

In a "circuit closer," or "C.C." system, each mine contains a small piece of apparatus which is set in action by the blow of a vessel against the mine, and when set in action completes an electrical circuit through the mine, through which the mine can be fired, if the main switch on shore has been closed. If it is not wished to fire, the "C.C." is restored to its ordinary condition either automatically by the action of a spring in the mine, or by an electrical device operated from the shore.

Such mines are necessarily placed near the surface, and are to this extent an interference with friendly traffic, though a vessel passing by mistake through a minefield of this class would run no risk of an explosion while the mines are inactive, but would possibly foul some of the mines and drag them out of position, or even sink them.

This class of mine is used in side channels which it is intended to entirely close, or to reduce the width of navigable channels where too wide to be defended by observation mines. The advantage of "C.C." mines is that if the firing switch is closed they are effective in fog or mist, when observation mines could not be worked, and when the guns of the defence would be equally out of action. They are also easy to lay, and the charge can be comparatively small.

It may be here stated that very early in the British Service the use of the dangerous mechanical mine was abandoned, except for laying in an hostile port by the Navy, and all British mine defences were composed of the electrical class.

The attack of ships and bridges by floating mines, which were **1682.**
allowed to drift towards the objects to be operated against, was attempted as far back as the 16th century; and the application of self-acting mechanical arrangements to the explosion of drifting mines appears to have originated with the English in 1682, who employed them in their operations against the French fleet off Rochelle. Some drifting torpedoes, provided with self-acting contrivances, devised by an American, Mr. Bushnell, were used, but without success, against the English fleet off Philadelphia in 1777. **1777.**
Another American, Mr. Robert Fulton, submitted to the French Government in 1780 plans of a submarine boat and of explosive machines, to which he gave the name of *Torpedo*. He appears to have received but little encouragement in France, and, upon learning that the English were employing explosive machines, known as Catamarans, against the French flotilla off Boulogne in 1804, he proceeded to lay his invention before the English Government. A few unsuccessful trials of his clockwork torpedoes were made in 1805 **1805.**
against the French vessels, but eventually a successful experiment was instituted with them off Walmer Castle in that year, when the *Dorothea*, a brig of 200 tons, was destroyed by two of his self-acting drifting torpedoes.

1812. In 1812 experiments were made with Fulton's torpedoes in America, and some attempts to apply his inventions to the destruction of English ships appear to have been made in 1813.

For many years after that period no prominent instance occurred of a proposal or attempt to apply submarine charges to purposes of defence or attack. Attention was however again directed to torpedoes in England for a short time by the consideration given to some secret contrivances for the destruction of ships submitted to the Government by Capt. Warner in 1844. These explosive machines appear to have been rendered self-acting by clock-mechanism, and to have furnished no evidence of superiority over Fulton's torpedoes. About the same time Colonel Colt in America developed a system of mines, and is said to have got as far as designing a circuit closer.

1854. The mechanical torpedoes employed by the Russians in the Baltic in 1854 were apparently the first engines of this class which have furnished any decided proof of their efficiency, and though the construction of the exploding arrangement was defective in some important respects, there is little doubt that these torpedoes might have been very formidable agents of defence if the charges of gunpowder which they contained had been heavier. Several contrivances for exploding torpedoes by mechanical agency were devised by the Federals and Confederates in the Civil War, and some of these appear to have been of considerable service in the defence of rivers, etc., though it is certain that only a small proportion of those over which vessels passed were successful in their action.

Electricity was first applied to the explosion of submerged charges by the late General Sir Charles Pasley, R.E., in destroying the wrecks of the *Royal George* and *Edgar* in 1839 and subsequent years. Since then electrical arrangements have been applied to purposes of submarine demolition, and during the Russian War some large iron cylinders, fitted with arrangements for the explosion of their powder charges by voltaic electricity, were despatched from this country with a view to the destruction of the sunken vessels in Sevastopol harbour, but were not used. A detailed plan was also submitted to the Admiralty at that period for applying similar means to the opening of a passage through an obstruction to the approach of Cronstadt on the north side, which had been sunk by the Russians, and which consisted of a line of large timber cribs filled with stones. Some torpedoes, designed for explosion by electricity upon collision with a ship, and which furnished the first examples of the application of electricity to self-acting torpedoes, were discovered in a barge at Yenikale by naval officers connected with the Kertch
1855. Expedition in 1855, but no evidence exists that torpedoes of this kind were actually employed by the Russians.

In 1855 Sir Charles Wheatstone represented to General Sir John F.

Burgoyne the importance of an experimental investigation into the comparative merits of different sources of electricity, as agents for the explosion of gunpowder in mining and submarine operations, whereupon the Ordnance Select Committee (of which Sir Charles Wheatstone and Mr. F. A. Abel were then members) received instructions from the Secretary of State for War to carry on researches in this direction, and an extensive series of experiments was instituted at Woolwich with the principal varieties of electrical apparatus.

In 1857–8 a series of experiments was carried on by Mr. Abel, 1857.
with the co-operation of Capt. H. Y. D. Scott, at Chatham, on the explosion of submarine charges by means of a fuze of his invention and with magneto-electric instruments devised by Sir Charles Wheatstone and Mr. Henley. The results of these experiments were reported to the Secretary of State for War by Messrs. Wheatstone and Abel in 1860. Baron Von Ebner, of the Austrian Engineers, also carried out experiments at about the same period on the explosion of torpedoes, which resulted in the adoption of a system of electrical torpedo defence at Venice, whereof the prominent features of novelty consisted in the employment of guncotton as the destructive agent in place of gunpowder, and of frictional electric machines as the exploding agent.

No instance of the actual operation of torpedoes exploded by electricity appears however to have occurred previous to the American War. The employment of mechanical torpedoes by the Confederates was speedily followed by the application of voltaic electricity to the explosion of submerged charges by judgment from shore stations. The arrangements were in the first instance of a very crude description, and only one or two instances of their successful action are on record. After a time however they received considerable improvements, more especially at the hands of Capt. M. F. Maury and of Mr. G. W. Beardslee; but the individual systems of electric torpedo-defence devised by those gentlemen were not fully matured until after the termination of the war.

But in spite of the crude nature of the apparatus and the want of 1862–1865.
knowledge of the operators, the mine and torpedo were effectively used during the American Civil War, no less than 37 vessels being disabled or destroyed between December, 1862, and June, 1865.

The effect of this new system of warfare was so marked that all nations who aspired to naval power had to take this new factor into account.

In 1866, during the Austro-German War, the Istrian and Dalmatian coasts were defended by a very complete system of mines devised by Baron Von Ebner, colonel of the Austrian Engineers.

Between 1864 and 1870 the Dutch, Danish, Swedish, and French Governments were all experimenting with mines, while the Chinese had some designs for a form of mine, probably produced quite independently of the European or American patterns.

1870. In 1870, in the Franco-German War, the German ports were defended by mines, and the defence proved sufficiently effective to keep the French fleets, which were in overwhelming force, at a distance, though how far this was due to the mine defence is a disputed point.

1878. In 1878, during the Russo-Turkish War, mines proved to have a very great moral effect, and a Russian gunboat, the *Suna*, was sunk by a mine.

1898. In the Spanish-American War of 1898 the U.S. ship *Maine* was mysteriously sunk by an explosion, believed to have been by a mine.

Mines were also used by the Spanish in the defence of Santiago and other ports.

In the United States itself the threat of the approach of the Spanish fleet was sufficient to cause a demand for the complete manning of the coast defences, in accordance with which the mine defences were laid out at New York and other ports on the East Coast. Apparently the greater part of these defences consisted of non-controllable mines, which blocked the harbours equally to friend and foe, and caused such a panic that commerce was very seriously affected.

Acting on this experience, the United States have since developed a complete system of electrical controlled mines.

1904. The Russo-Japanese War of 1904–05 offers at Port Arthur the most recent example of mine warfare. On both sides only the non-controllable class was used. This was, of course, essential in the case of the attack, but was suicidal on the part of the defence, as the ingress and egress of their own ships was seriously affected.

Also it cannot be said that the Russian system was an engineering success, as one of the first casualties reported was the loss of the mining steamer *Yenesei* while laying mines.

The losses on the Russian side due to mines were the *Petropavlosk* sunk on 13th April, 1904, and the *Pobieda* damaged, the *Sevastopol* damaged on 19th June and again on 23rd August, while some 8 or 10 smaller ships were sunk or damaged at different times.

On the Japanese side the battleship *Hatsuse* was blown up on the 15th May, the *Fuji* damaged, and the cruiser *Yoshino* was sunk, while the cruiser *Kaimon* was sunk on 3rd July.

In addition several smaller vessels were sunk in the various operations of laying or clearing mines round Port Arthur and Dalny.

The mines also had a large share in repelling the blocking attacks of the Japanese. In the third attack of this description, on 3rd May, 1904, four of the blockers are said to have been sunk by mines.

The operations of sweeping for mines and clearing channels was carried out on both sides with great vigour, but countermining, tried by the Russians, appears to have proved ineffective.

On the Japanese side most of the principal ports were mined, but a very simple and effective system of traffic inspection was established, and friendly shipping of all classes was admitted in daylight.

No movement of such shipping was allowed at night, but due notice of the regulation was given to all ships using Japanese ports, and no practical inconvenience arose from the enforcement of this regulation.

Though no attack was made on Japanese ports, the value of fixed defences was several times shown during the raids of the Russian Vladivostock squadron. On one occasion this squadron got within a few miles of Tokio, but the security given by the defences enabled the Japanese to keep their fleets at the strategic centres, confident that beyond the loss of a few merchant ships no damage would be done, and that they would drive the Russians back to their port whenever they wished so to do.

On the 20th July, 1863, General Sir John F. Burgoyne, Bart., **1863.** G.C.B., Inspector-General of Engineers, who had for some years watched with keen interest the development of torpedoes, issued a "Memorandum on Floating Obstructions and Submarine Explosive Machines," which may be considered as the official starting point from which sprung not only the military system of mines, but also all naval mines and torpedoes in the British Service, and the systematic use of passive obstructions.

This memorandum was worded as follows:—

DEFENCE OF HARBOURS.

Floating Mines and Obstructions.

"There cannot be a doubt as to the great power to be derived from the application of floating or submerged mines and artificial obstructions as an accessory of defence against the passage of an enemy's vessels through narrow or comparatively narrow channels; but we have as yet only vague notions of systems for their employment. The experience of their application has been very small and imperfect, and even the propositions for a manner of proceeding have been rare and apparently not much considered.

"It is therefore a subject well worthy of investigation and experiment, and having long held that opinion, and established certain principles in my own mind for the enquiry, I would offer them as matters among others for consideration.

"The subject may be divided into two general heads:—

1. Floating or submerged mines.
2. Passive obstructions to the progress of the vessels.

"First.—The mines may either be made to float on the surface or to be suspended by floats to any required depth. On the surface they would be capable of being more rapidly and safely attached to or removed from their moorings (a measure that might frequently be convenient) than if they were sunk; but it would be difficult to prevent their being somewhat more conspicuous than the floats that could be devised in the latter case, and if to be fired by collision they would be more susceptible of being prematurely exploded by means the enemy might employ to precede him for the purpose.

"These mines (or *torpedoes*, as sometimes called) may be made for explosion either by galvanic batteries from the shore or by concussion or collision with the vessel, either of which methods may be useful or preferable under special circumstances. The first would have the great advantage of little or no danger of accidents in stowage, removals, or handling even roughly, and would be perfectly harmless to our own ships, which might be in collision with them without the least danger; the objection would be the great difficulty of knowing precisely when the enemy's ship is in absolute contact with them.

"The more prevalent and favoured idea is ignition by the concussion of the vessel striking one of these in passing. A leading evil of this system is the apprehension that it might act against friend as well as foe, and thus cripple the means for the passage generally and for sallying out upon the latter on favourable occasions.

"Another difficulty and matter for research would be how to contrive that the machinery should be delicate enough to *ensure* the effect by the action of collision with the ship, and still hard enough not to allow the waves or trifling contact with weeds or small matters, or means employed for the purpose by the enemy, to explode them prematurely; but the most serious consideration is how to apply them in a manner that will enable them to be handled with safety. If this could be done so as to be thoroughly effective it would admit of frequent removals, and consequently of their being placed in position only at and during the particular periods of the last emergency.

"Among the many means that may be proposed for the ignition of the charge by collision, I am only aware of two, descriptions of both of which are in possession, it is believed, of the Admiralty—one is that actually employed by the Russians in the Baltic, the invention of Professor Jacobi, which, in many cases, effected the ignition on contact; the other is that of Capt. J. Harvey, R.N., who has given much consideration to the subject. The first is effected by a sliding lever, which, being pressed to one side, breaks a bottle within, and thus procures a well-known chemical combination that causes ignition; the other by an inclined projecting lever, which, being pressed down, produces the same effect by a similar combination or by some mechanical operation.

"The Americans have also contrivances for the purpose, of which it would be desirable to have a knowledge, as they are very ingenious in such matters.

"Among the many details that have to be considered and tried for producing from floating mines the best results in efficiency, combined with economy, there will be:—

1. The form and position of the mine.

"An important object is that the charge of powder should be in close contact with the object to be acted upon. In the Russian contrivance the charge was placed in the apex of an ordinary conical buoy, by which there would be some feet of intervening water, which decidedly should be avoided; an oblong cylinder would probably be the most convenient shape, so adjusted as to bring its longitudinal side in contact with the ship under any circumstances of current or movement of the water.

2. The charge and nature of its receptacle.

"The amount of charge has yet to be ascertained by experiment, not by one so costy as the sinking of a ship, but against rafts in a rough state, that, by analogy, would give well-founded approximate results; and where the object is destruction, there can be no mistake in applying a little too much powder. The charges applied by the Russians of 12 or 14 lbs. were decidedly too little, even against the timber ships. No amount could possibly be required for any occasion but what would occupy a very small space. The case to contain it may be of any material, metal or wood; the slighter and smaller the better, provided that in size it will contain the charge easily, and be strong enough for its object. The powder, being made up in thoroughly waterproof bags of a construction that has already been proved at the Royal Engineer Institution at Chatham, will remove the necessity for the case being water-tight, and will be found convenient in other respects.

3. The system for igniting the charge.

"Where it is to be effected by galvanic battery from the shore, the shed or apartment for the battery may be very small, and would, of course, be effectually covered and protected from the enemy's fire, the connecting wires protected from external injury, and following the ground line under water to the mooring chain or rope with which it will be connected up to the charge, and fixed so as to prevent derangement by any action of the mooring, or of tides, etc.

"To expedite the placing of the mines in required positions, in many cases it may be most expedient to lay down the moorings and wires for periods more or less long, and apply the mines from time to time, as emergencies may arise, by some simple operation of substituting them for an ordinary buoy to the moorings, and attaching the two ends of the wires, to effect the circuit of the electric current.

"To provide for the only difficulty in this system, that of knowing at the battery when the ship is absolutely in contact with the mine, it may, perhaps, be possible to have some signal sound or small explosion in or near the battery, produced by the contact, that might give the required notice; or to place a certain number in a line, say four or six, at such distances that it could readily be perceived that the ship, in passing, must be in contact with one, and then exploding all simultaneously, the effect could hardly fail.

"Where the ignition is to be by collision, the system that will produce the most certain effect at the proper time, with the fewest chances of premature explosion, either by accidents or efforts of the enemy, is still for experiment; and what is a most important ingredient, one that will admit of handling and removals by ourselves with entire security from accidents. This will be more peculiarly difficult with mines that are partially submerged, and may be sufficient reason to reject that principle altogether, as an increase of charge to the floating mine will render it equally effective. If the manner of security from accident in handling them could be managed by some special apparatus, an enemy, not being prepared with it, would find it dangerous to tamper with them.

4. How to prevent the enemy avoiding or counteracting the effect of the floating mines.

"On *seeing* them he would, no doubt, by his steering try to avoid collision with them, to prevent which they might be too numerous, or even without that extended provision there might be what may be called *dummies*, or common buoys of the same appearance, interspersed with them, and it would be impossible to distinguish the real from the false; or the enemy might employ, immediately preceding the attack, rafts or other floating matters to drop with the current and cause by their collision premature explosions, and it might be desirable to endeavour to contrive some slight float moored before the mine so as to turn such loose floats from impinging upon it.

"Secondly.—With regard to *passive* obstructions to the progress of an enemy's vessels, the only ones applied of old were booms of chains and timber; they would certainly be troublesome and costly in their application, and were so often broken through by the enormous impetus of a heavy ship that it would be hard to find on record where they had proved effective.

"One of the expedients to render them so would be to multiply them by the addition of a second, which might perhaps catch the vessel after her impetus was checked by forcing the first. This however would be doubtful, and, at all events, a second vessel would come fresh upon it. The position of the boom may be improved by being laid in a slanting direction, by which, without receiving the full force of the vessel, it might turn her bow on to the shore.

"These booms however may still be applied partially; but a much more simple, effective, and readily applied *impediment* may be found against steamers by old rope, spunyarn, and shreds of old sails, and other ingredients, mixed perhaps with floated chains and spars, and thickly moored and floated in the channel, it is hard to conceive how any steamer could penetrate through such a mass.

"An objection made to this application is that it would obstruct friend as well as foe; but that need not be. The impediment may cover only a part of the channel, leaving the opening for navigation either close to or directed in the most favourable manner for bringing the fire of the defensive batteries to bear upon the enemy.

"Thus, supposing a channel between powerful batteries to be 2,000 yards wide, by fixing the obstructions along a line in the middle of 1,200 yards, the ships would have only a free passage of 400 yards wide by which to penetrate, and consequently at not more than 200 or 300 from either battery; or the passage (well defined for our own vessels) may even be made tortuous to be more difficult for the enemy, and through this he never could find his way while the smoke of an engagement was hanging over it.

"One great advantage of the whole of this system, whether of floating mines or obstructions, would be their small cost, and that they could be quickly prepared and applied or removed, and therefore they might be greatly multiplied; whatever is of most value, such as moorings and galvanic batteries, would not be consumed, but would remain to the good; the moorings indeed would be light, and of the most inexpensive character, nor is there any part of these operations that could not even now be readily provided and adjusted in a rough way, but it is most desirable to ascertain how to do it all on the best system.

"There are two accessories to the application of all these impediments that may be worthy of attention.

"One is that they ought to be watched and guarded from being tampered with, not only by the fire of the batteries which support them, but at night by small armed steamers which, it is presumed, will henceforth take the duties performed by boats '*rowing guard*,' and which would capture or run down any boats of the enemy sent to meddle with them; the other is that the floating batteries to co-operate in the defence may be greatly multiplied at a comparatively small expense by the employment and fitting up of lighters or rafts for them, with no steam power of their own, but dependent on the small private steamers of the locality, which at times of emergency could tow them in and out of their respective positions."

(Signed) J. F. BURGOYNE, I.G.F.

War Office, July 20th, 1863.

On 8th September, 1863, a joint Naval and Military Committee was appointed to investigate the questions referred to in this memorandum.

WAR OFFICE,
September 8th, 1863.

SIR,

I am directed by Lord de Grey and Ripon to inform you that, having been in communication with the Lords Commissioners of the Admiralty respecting the appointment of a Committee to consider and report on the use which may be made of floating obstructions and submarine explosive machines in the defence of channels, their Lordships have signified their approval of your being appointed President of the Committee in question.

Capt. Horton, R.N.
Col. F. A. Campbell, R.A.
Lieut.-Col. Gallwey, R.E.
J. Fergusson, Esq., F.R.S.
F. A. Abel, Esq., F.R.S.

The members appointed to aid you in the investigation of the subject are as named in the margin, and I am to request that you will be good enough to communicate with them, and assemble the Committee for the purpose of taking into consideration, and reporting for the information of Lord de Grey, the manner in which the Committee propose to conduct the inquiry.

Lord de Grey directs me to transmit, for the information of the Committee, the enclosed copy of a memorandum on the subject by Sir John F. Burgoyne, dated 20th July, 1863, and I am to express his

Lordship's desire that the investigation of the subject should be conducted with as little publicity as possible.

I am to add that accommodation will be provided for the Committee at 109, Victoria Street, and Lord de Grey would be glad to know whether you have any suggestions to make as to the appointment of a Secretary.*

I am, etc.,

Rear-Admiral Wellesley, C.B., EDWARD LUGARD.
Kelmarsh Rectory, Northampton.

The enquiry undertaken by this Committee consisted of two distinct branches; the one related to the application of *passive* obstructions for closing of channels and rivers, while the other had reference to the employment of submarine mines and explosive machines for offensive or defensive purposes. The Committee proceeded simultaneously with the investigation of both subjects, but the great variety and extent of the experimental and other enquiries necessary for a thorough examination into the merits of *active* obstructions and the conditions to be fulfilled in their efficient application made it impossible for them to submit at an earlier date anything approaching a complete report on this subject. Thus their first report, dated 1st August, 1866, dealt with passive obstructions only, and it was not till July, 1868, that they completed their report on active obstructions.

The work of the Committee, under the second of these heads, fell into three main groups.

1. The nature of the explosive agents to be employed, whether guncotton, fine grain or large grain powder.

2. The dimensions of mines and torpedoes, the material suitable for their construction, and the best form to be given to them; the arrangement of the charge and of the exploding arrangement or fuze. This required entirely different treatment for mines and torpedoes.†

3. The mooring and arrangement of mines.

* Commander Wm. Dawson, R.N., was appointed to act as Secretary on the 29th September, 1863. Colonel (afterwards Major-General) Wm. H. Askwith, R.A., was appointed on the 11th November, 1863, to succeed Colonel F. A. Campbell, R.A.; and Lieut.-Colonel A. A'C. Fisher, C.B., R.E., on the 8th February, 1864, to succeed Lieut.-Colonel T. L. J. Gallwey, R.E. Rear-Admiral G. G. Wellesley, C.B., was removed from the Committee on his appointment to the Superintendence of Portsmouth Dockyard, on the 30th June, 1865. Capt. T. Brandreth, R.N., was appointed on the 4th May, 1866, and removed from the Committee on the 12th March, 1867, on his appointment to the office of Private Secretary to the First Lord of the Admiralty.

† For the sake of clearness, the terms "mines" and "torpedoes" are used here and in future chapters in their modern sense. The Committee used the term "torpedoes" for both classes.

At the outset the information at the disposal of the Committee was very meagre. They had reports on the American contrivances used in the Civil War, partly from the inventors themselves, and partly from the reports compiled by Capt. E. Harding Steward,* R.E., and Capt. C. Hardy, R.A. Also the reports of a series of experiments carried out in 1855–60 by Sir Charles Wheatstone, Mr. F. A. Abel, and Lieut.-Colonel H. Y. D. Scott, R.E., in connection with the Ordnance Select Committee on the application of electricity to the explosion of gunpowder, and a considerable amount of information on the use of explosives for the destruction of wrecks, starting from the work of Sir Charles Pasley in 1835 onwards.

On the important question of the strength and nature of the charge, the Committee had at their disposal the report of experiments conducted on board H.M.S. *Excellent* in 1846–53 with gunpowder, but they were on a small scale.

This latter question was further complicated by the invention by Mr. F. A. Abel, the War Department chemist, of compressed guncotton, while the discovery by Mr. G. O. Brown that guncotton could be detonated in the open air opened up new fields for experiment, and put out of date much of the earlier work of the Committee.

For the purpose of obtaining further data required by the Committee, several series of experiments were carried out at Chatham between 1864 and 1868 under the control of Capt. and Brevet Lieut.-Colonel A. A'C. Fisher, R.E., who had joined the Committee in 1864. The Directors of the Royal Engineer Establishment during this period—Colonel H. D. Harness, C.B., R.E., and Major-General J. L. A. Simmons, C.B., R.E.—rendered valuable assistance, and Lieuts. Mascall, Ommanney, and de Wolski were specially mentioned for their services. The name of Q.M.S. J. Mathieson, R.E., well known to later generations of submarine miners, also repeatedly appears in this report. **1864–1868.**

Most of the experiments at Chatham were against targets of planks bolted together, a few against iron plates, and one took place against the *Terpsichore*, a wooden 18-gun sloop of 603 tons.

Measurements were also made of craters formed on the mud in the Medway, and a similar series was carried out at Weston-super-Mare in 1868 with charges under different heads of water.

In addition to this, a series of experiments was carried out by the officers of H.M.S. *Excellent*, under Capts. A. Cooper Key, C.B., and A. W. A. Hood, to determine the best charge for outrigger torpedoes. These experiments were conducted against the wreck of the *America*, a 74-gun ship of 1,758 tons.

* A paper by this officer was published in the *R.E. Professional Papers*, 1867, and had much influence in determining the future use of mines in the British Service.

Just before the conclusion of their work the Committee pointed out that experiments against wooden ships—though of value—did not furnish accurate data as to the effect of mines on iron ships, and suggested that a shield representing a portion of the bilge of one of the most strongly constructed iron ships, fixed to a wooden hulk, should be provided by the Admiralty. This proposal was supported by the War Office, but the Lord Commissioners of the Admiralty replied that "they do not feel justified in incurring the expense."

1868. The Committee signed the final report in July, 1868, and a summary of their conclusions contains much of interest.

On the first head, the strength and composition of charges, the Committee definitely recommended that guncotton should be used in preference to gunpowder, even though at that time the modern methods of detonation had not been fully established. Their reasons were that guncotton is as effective as four times its weight in gunpowder, that it is equally cheap, and that the reduction in weight would enable considerable reduction to be made in the size and weight of mines and torpedoes. They further reported that 100 lbs. of gunpowder in close proximity to a ship should produce decidedly destructive effects, and definitely recommended this weight of charge or its equivalent of 25 to 30 lbs. guncotton for outrigger, stationary, or drifting mines or torpedoes of a directly self-acting nature. They further recommended that mines moored at depths greater than the depth of immersion of the larger ships of war should be of such dimensions that their explosion shall exert a horizontal destructive action of not less than 20′ to 25′ radius. In such work they recommend 1,000 to 1,200 lbs. of gunpowder, or 300 to 400 lbs. of guncotton. Considerable time was given in their experiments to the thickness of case necessary to develop the maximum effect from the charge. This was at first very important, as heavy cases were necessary to ensure the full explosive effect of gunpowder, while, on the other hand, a heavy case involved considerable size of air chamber to render it buoyant. But these considerations practically vanished when it was discovered that guncotton could be detonated.

On the details of firing, the Committee strongly recommended the use of electricity as the firing agent, and that mines should be susceptible of explosion by judgment from the firing stations, and should also be provided and placed in electrical connection with self-acting arrangements. These latter to be capable of being rendered safe for the passage of friendly ships, and not to be injured by accidental blows or very long immersion.

In the matter of the best method of mooring, the Committee were satisfied with pointing out the difficulty of mooring in a tidal river, owing to the effect of the current on the mine and its mooring gear, and suggest that further experiments should be carried out with certain arrangements suggested by them. Among other details they recommended voltaic batteries, and Abel fuzes, and the use of Hooper's insulated wire (then just selected for field telegraphic purposes) as the conducting wire. An insulated joint, very similar to that with which all submarine miners were so familiar, was also recommended.

In short, the report, which with its appendices covered 235 pages of foolscap size with over 50 plates, is not only a monument of industry, but a lasting memorial of the skill and intelligence with which a new and intricate subject was attacked by the Committee. It may fairly be said that the result of their experiments was to start British Submarine Mining on definite lines, which were never departed from.

On the general question of the value of mines the Committee reported as follows:—

"The Committee believe as the result of their investigations that they are not exaggerating the future importance of active obstructions in regarding them not only as most invaluable auxiliaries to permanent coast and river defences, but also as affording the means of defending positions on a coast or small channels or rivers which are unprovided with defensive works. But it is, on the other hand, most important that the probable value of submarine mines and their efficiency as defensive agents should not be over-estimated, and that the opinion should not be for an instant entertained that permanent works of defence could be dispensed with by the application of a system of defence by submarine mines. However perfect all arrangements for the application of these engines of war may be, they must always present two important inherent defects which reduce their functions as agents of defence within much narrower limits than those of the artillery of the present day. On the one hand, powers of destruction possessed by submarine mines are confined to a very limited area, as compared with those of a gun in a fort, and although they are much more formidable when brought into play, they necessarily remain inert until a ship advances into the narrow sphere of their action. Again, any single submarine mine can only act once, and the area of water protected by it is afterwards left defenceless. It is therefore evident that submarine mines can never actually replace artillery, and that, wherever they are employed, their value as defensive agents will be very greatly increased if they are brought to bear as adjuncts to artillery defences."

The report on active obstructions was finally signed in July, 1868, by the following:—

W. H. Askwith, Major-General, Royal Artillery, Chairman,
W. Horton, Capt., Royal Navy,
A. A'C. Fisher, Lieut.-Colonel, Royal Engineers,
James Fergusson, F.R.S.,
F. A. Abel, F.R.S.,
and W. Dawson, Commander, Royal Navy, Secretary.

One other point may be noted. It is assumed throughout the report that all experiments with torpedoes would be carried out by the Royal Navy, and all experiments with mines would be carried out by the Royal Engineers.

The reason given was that the Royal Engineers already received at Chatham instructions in the operations connected with field telegraphy and the explosion of mines both for land defence and the destruction of wrecks, and it was only necessary to somewhat extend this instruction and to add a practical course in the mechanical operations of preparing and laying down a system of submarine mines.

A reference is made to the fact that courses with this latter object were started at the Royal Engineer Establishment in 1867, and that at Portsmouth instruction in torpedo service had been included in the course of gunnery instruction in H.M.S. *Excellent.* Several of the naval instructors in gunnery, of which Lieuts. J. A. Fisher and H. E. Kane were specially mentioned, went through courses at Woolwich in 1867 under Mr. G. O. Brown, the Assistant Chemist to the War Department, and on their return to the *Excellent* the naval courses referred to were successfully established.

The consideration of this report should not be completed without special reference to the work done by Capt. and Brevet Lieut.-Colonel Fisher in connection with submarine mining.* As the only Engineer member of the Committee the burden of most of the mine experiments at Chatham must have fallen on him. He remained at Chatham in charge of experiments till October, 1870, when he left for Bermuda, and definitely severed his connection with submarine mining.

Meanwhile the general supervision of the submarine mining work had passed to Capt. R. H. Stotherd, R.E., who was senior regimentally to Lieut.-Colonel Fisher, and who had joined the Engineer Establishment in 1866 as Superintendent of Schools, his duties including telegraphy, signalling and demolitions, to which was now added submarine

* Colonel Fisher had a most distinguished career, and but for his early death would have reached a very high position. Born in 1830, he was commissioned in 1847 and joined the Army in the Crimea in 1855. He took part in the attack on the Redan on 18th June, 1855, and in October, 1855, was in charge of the Field Telegraph (21 miles and 8 stations); commanded the 10th Company, R.E., in Canton and China 1858—1860; received the Brevet of Major in 1858, and Lieut.-Colonel and C.B. in 1860. He was employed at the War Office under Jervois from 1860 to 1864, and in December, 1864, became Instructor in Surveying at the S.M.E., Chatham, which he held till 1869, carrying on simultaneously the mining experiments. On leaving the S.M.E. he served as Executive Officer and C.R.E. at Bermuda, Aldershot, and Malta, and died at Inverness in 1879.

mining. The Royal Engineers were even then experts in destroying wrecks. They had also devoted considerable attention to the firing of land mines and charges for demolitions, and had in use for these purposes a wire fuze and electrical firing arrangements, on which the firing apparatus of submarine mining was based.

Capt. Stotherd worked hard to improve the apparatus, and instituted regular courses of instruction, so that the system might at any time be adopted for actual service.

He also endeavoured by lectures at Chatham, and the R.U.S.I. in London, to spread a knowledge of submarine mines. These lectures were brought together in book form and published at the S.M.E., Chatham, in 1871, under the title of *Notes on Defence by Submarine Mines*, forming the first manual of instruction in the British Service.

The term "submarine mine" is first systematically used in this publication.

Capt. Stotherd's assistants were Lieut. S. Anderson, R.E., who was Assistant Instructor in Telegraphy and Submarine Mining, and Lieuts. O. Chadwick, H. Jekyll, J. T. Bucknill, R. F. Moore, and R. Y. Armstrong; while Capt. Harding Steward, who was stationed at the War Office, appears to have contributed many useful suggestions. Mr. F. Abel, the W.D. chemist at Woolwich Arsenal, was also indefatigable in experiments with patterns of fuzes and firing arrangements generally.

Some of the experiments of this time were rather curious, such as the attempt to drive surface torpedoes through the water by means of rockets, but on the whole good progress was made.

On 27th July, 1870, the Director of Works and Fortifications **1870.** (Colonel Jervois) wrote to the Inspector-General of Fortifications (Sir F. Chapman), pointing out that a large sum of money was proposed to be expended in the purchase of mine apparatus and recommending that the following Committee be appointed to report on the form, composition, and machinery of mines, viz.:—

Lieut.-Colonel C. H. Nugent, R.E., President,
F. A. Abel, Esq., F.R.S.,
Capt. R. H. Stotherd, R.E.,
Lieut. S. Anderson, R.E.,
And a naval officer.

This was approved by Secretary of State for War (Mr. Cardwell) on the same date.

Navigating Lieut. S. C. Tracy, R.N., was nominated by the Admiralty, and was replaced 23rd August, 1870, by Navigating Lieut. C. W. Langdon, R.N. In January, 1872, Lieut. W. H. Hall was added to the Committee. Lieut.-Colonel Nugent was ordered home specially for this Committee, and was employed at the War

Office in charge of the branch which subsequently developed into the office of I.S.D.

It is interesting to note, as fixing the relative position of the period under consideration, that in 1870 the Engineer branch of the War Office had just been reorganized. The Inspector-General of Fortifications was Sir F. Chapman, K.C.B., Colonel W. D. Jervois, C.B., was Deputy Director of Works, while Lieut.-Colonel Hon. H. F. Keane was Deputy Adjutant-General.

Colonel T. L. J. Gallwey* was Commandant, S.M.E., and President of the R.E. Committee, which had been reconstructed in 1866. Lieut.-Colonel Wray, Capt. and Brevet Lieut.-Colonel W. Lennox, Capt. Stotherd, and Mr. F. A. Abel were the members of the R.E. Committee, and Capt. Home was the Secretary.

The A and B Troops were in existence at Aldershot, but field companies were not formed till 1876.

The Telegraph Service started into being with C Telegraph Troop, formed in August, 1870, under Capt. Lambert, while a few months previously the 22nd Company had been attached to the Post Office for telegraph work under Major Webber.

The Torpedo Committee did not take long in getting to work, and on the 3rd October, 1870, presented a first report. This is especially interesting as showing the state to which the mines and apparatus had been brought at this date.

They regarded as firmly established :—

1. The form, dimensions, and construction of the mine cases.
2. The nature of explosive agent.
3. The nature of electric cable.
4. The forms of battery.
5. The arrangements for mooring.

And as open to discussion :—

6. The kind of fuze.
7. The form of circuit closer.

These two points however were open only in respect to two fuzes and two circuit closers. Both fuzes and both circuit closers were reported efficient and either system could have been used, but further experiments were necessary to determine which should be eventually adopted.

* Colonel Gallwey during his period as Commandant, S.M.E., from 1868 to 1875, took the greatest interest in submarine mining and helped it forward in every way in his power, especially by the careful selection of officers, N.C.O.'s, and men to form the new companies.

The Committee forwarded detailed specifications and drawings of many of the stores they recommended.

This report was submitted to the War Office, and on the 20th October, 1870, was referred to an influential Committee, under the presidency of Sir Frederick Chapman, K.C.B., the Inspector-General of Fortifications. The members were Major-General Lefroy, C.B., R.A., Capt. Sir Leopold Heath, K.C.B., R.N., and Capt. Morgan Singer, R.N., with Lieut.-Colonel Nugent as Secretary.

Their duty was to consider the material and apparatus actually required to provide for the efficient defence of each position with the best disposition thereof, including the lighters and boats required at each station for mooring and laying down the torpedoes, the store-houses necessary for the thorough protection of the whole of the material, and the staff of operators and men required.

They were asked first to report on certain lists of stores prepared by the Torpedo Committee, so that purchases could proceed at once, and then to consider the application of the system to the principal military ports.

Following these instructions the Committee, which first met on 28th October, reported on 12th November, 1870, that the stores referred to would certainly be required for the principal harbours of the United Kingdom only.

They then considered all ports at home and abroad in detail, and **1871.**
submitted a final report on 30th August, 1871, of which the following extracts are of interest :—

"The Committee adopted the report of Lieut.-Colonel Nugent's Committee, except as regards certain details.

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"The Committee are not disposed to place much reliance upon mechanical contact torpedoes; they close waters against *all* vessels, and their removal, when no longer required, is attended with much risk.

"Cases may however arise in which they may be applied with advantage, such as when it is absolutely necessary to close a channel or other water with extreme rapidity, even though by doing so it be denied to friendly vessels.

"The Committee therefore do not ignore mechanical contact torpedoes, especially as a design for a new torpedo of this description, recently submitted to the Torpedo Committee, promises good results.

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"The Committee considered the submarine defence of :—

(*a*). The military stations at home.
(*b*). The military stations abroad.
(*c*). The great commercial ports of Great Britain.
(*d*). Other places which, for military or political reasons, it seemed necessary to consider.

"The great commercial ports may be stated as those ports which have a trade so large that it forms an important part of the general trade of the Empire, and any extensive injury falling upon them would be felt as a national disaster.

"The other places comprise important anchorages and roadsteads, commercial ports of less importance, and places favourable for the disembarkation of an invading force.

"Submarine mines cannot however be applied to all places; in some, the configuration of the coast line and the nature of the adjacent water preclude them; in others, the rise and fall of tide and the sweep and strength of current limit their application.

"Dover and Gibraltar are instances of the former; Swansea and the Estuary of the Severn are instances of the latter.

"For these reasons the Committee do not recommend the application of mines to such places.

"An establishment of lighters and boats will be necessary at each of the five principal stations in Great Britain and Ireland, viz.:—

1. The Medway, with which the Thames is included.
2. Portsmouth.
3. Plymouth.
4. Pembroke.
5. Cork.

"A few establishments will suffice for all the other places, which should be arranged for this end in convenient groups.

"The establishment should consist of a paddle-wheel steamer, two steam launches, and a lighter.

"Vessels not unsuitable for these purposes may no doubt be found in all the dockyards, but the Committee are of opinion that properly fitted steamers of the requisite size will prove the most economical; and as it is probable that in the event of war the dockyard vessels and appliances will be otherwise employed, they recommend that three establishments should be at once provided, being also under the impression that vessels so fitted will be available for ordinary dockyard purposes when not required for the training, exercise and instruction of the mining staff.

"The stores are not of a very perishable nature, and but little special arrangement is needed for their accommodation. It is probable that ample store-room may be found at all the military stations, and that special accommodation will have to be provided at the commercial and other stations only.

"The Committee have prepared and submit the drawing of a model store for 100 assorted mines complete; the cost is £445.

"In the present state of experience, the staff of operators required cannot be settled with absolute precision.

"The systematic practical instruction introduced some years back in the Royal Engineers has, from want of due extension, been able to do little more than keep the subject alive, but it has demonstrated the absolute necessity of maintaining a sufficient number of properly trained men.

"The electric operations connected with submarine mining are delicate and require special instruction; the observing and firing operations require judgment, discretion, and coolness.

"This mode of defence may be confidently relied on, but it depends upon the efficiency and skill of those to whom it is entrusted.

"In this respect it resembles artillery defence, and requires like it a special organization of a permanent character, with arrangements for periodical practice and an adequate expenditure of stores.

"The Committee on Floating Obstructions and Submarine Mines also felt deeply and expressed forcibly the importance of such provision.

"Considerable misapprehension prevails as to the value in warfare of submarine mining. Some seem to entertain the idea that in the defence of harbours and roadsteads it will supersede artillery altogether; while others, who do not take so extreme a view, would apply mines to every water, whether defended by the artillery fire of forts and armed vessels or no.

"The proper application of submarine mines is in conjunction with, and as auxiliary to the fire of artillery; employed thus, they will tend in future to diminish the expenditure on permanent works and armaments; but they must invariably be placed under the protection of guns, for torpedoes in undefended waters are at the mercy of any enemy of ordinary enterprise who has time and means at his disposal.

"The Committee are of opinion :—

1st. That mines should never be placed except under the protection of the guns of forts, or of armed vessels, or in localities where they could be protected by guns of position.

2nd. That they should be placed in advance of the forts, at a distance varying with the nature of the water to be defended, but which should seldom exceed 1,000 yards, up to which limit it may be assumed that the artillery of the defence will have a decided preponderance over that of the attack; but at any rate within which most ironclads are penetrable by guns of the present day.

3rd. That they should be protected by armed vessels, which would watch, especially at night, the movements of an enemy, and would prevent his boats from sweeping for or tampering with the mines.

4th. That it would be desirable to lay chain cables parallel to the lines of electric cables, so that an enemy shall not be able to lay hold of the latter by dragging.

5th. That secrecy be most rigorously observed with regard to the lines of defence, the localities in which the mines are placed, the charts of the operators, and the positions of the firing batteries.

6th. That dummies be liberally used to deceive an enemy, the dummies being in all respects exactly like the mines.

7th. That electric or other powerful lights should be treely used in all nocturnal operations, and the materials for producing such lights should be included in the stores for every complete system of mines.

"The labour of raising electric cables and mines to the surtace ot the water is very great, and the time lost in the operation might be irreparable. At all the most important stations there should be facilities for examining them as they lie on the bottom, and for this purpose divers should be included in the staff of operators, and diving apparatus should form a portion of every torpedo equipment.

"The Committee cannot conclude the present report without bringing to the notice of the Secretary of State the value and importance of the experimental researches conducted by the Committee, presided over by Lieut.-Colonel Nugent, R.E., and expressing their sense of the necessity of their further prosecution.

"The principles of electric and mechanical science, involved in these researches, are indeed well established, but the applications themselves are probably capable of great improvement in the direction of economy and simplicity."

FREDK. E. CHAPMAN, Major-General, President.
J. H. LEFROY, Major-General.
L. J. HEATH, Captain, R.N.
MORGAN SINGER, Captain, R.N.
C. H. NUGENT, Lieut.-Colonel, R.E., Secretary.

War Office, Pall Mall, 15th April, 1871.

Details of the proposed defences were given in the enclosures to the report, with cost.

The staff of operators for one principal station was laid down as 2 officers, 6 N.C.O.'s, and 44 sappers, and therefore for the three stations it was proposed to first take in hand—Thames and Medway, Portsmouth and Plymouth—there would be required 6 officers, 18 N.C.O.'s, and 132 sappers, which should be at once trained.

The cost of an establishment of vessels and boats was given as £7,000. It was recommended that three establishments, each of 1 paddle steamer, 2 steam launches, and 1 lighter, should be provided at once, and at least five should be eventually maintained in peace; in time of war it would be necessary to have eleven for home ports only.

The lists of stores accompanying the report, which was illustrated by over 60 charts, were divided into three groups.

The first group included all military stations at home—*Thames and Medway, *Portsmouth, *Plymouth, *Portland, *Pembroke, *Cork—the total estimated cost of stores being £172,291.

The second included all foreign stations—*Bermuda, *Malta, *Halifax, N.S., *Jamaica, Simon's Bay, Table Bay, *Mauritius, *Trincomalee, *Singapore, Point de Galle, *Hong Kong—with a total of £146,843.

The third included commercial and other ports at home—Aberdeen, *Tay, *Forth, *Clyde, Moray Firth, *Tyne, Sunderland, *Hull, *Yarmouth, Lowestoft, *Harwich, Littlehampton, Newhaven, Poole, Dartmouth, Exmouth, *Falmouth, *Severn, Holyhead, *Liverpool, Dublin, Waterford, Shannon, Galway, Lough Swilly, Lough Foyle, Belfast, Jersey, Alderney.

Mines were subsequently provided at those ports marked with an asterisk, to which were added later the Tees, Berehaven, and Esquimault.

The report of this Committee represents the first application ot the system of submarine mining developed by the Royal Engineers to the defence of our ports, and from this time onward this auxiliary arm had a definite place in all our schemes of defence.

CHAPTER II.

HISTORICAL.—MINES IN THE BRITISH ARMY.—2ND PERIOD—1871–1883.—EARLY GROWTH.

THE year 1871 is important in the history of submarine mining, not only in marking the commencement of the purchase of submarine mining stores on a large scale, but in the formation of the first submarine mining company and the appointment of a special instructor for submarine mining work. While the period selected as the subject of this chapter ends in May, 1883, with the departure from the *Hood*, which not only forms a definite end to the period of the early struggles for efficiency, but was the beginning of the large development of numbers and units associated with the name of Sir A. Clarke.

The work prior to 1871 was carried out by Jervois, Fisher, Stotherd, and Anderson. In the 12 years dealt with in this chapter we shall find the War Office work developing under Nugent, Stotherd, Anderson, and Malcolm, the training at Chatham increasing in efficiency under Armstrong, G. Barker, H. W. Renny-Tailyour, and R. M. Ruck, while a busy experimental centre was formed at Portsmouth under Stockley and Ramsay, and at all these centres the energy of Bucknill gave an added impetus to every branch of work.

During this period we find five R.E. companies formed and employed at 11 stations (eight at home and three abroad), while at five other foreign stations small detachments were gradually making preparation for the larger organization to follow.

A beginning was also made with the formation of the first S.M. Militia Corps.

1871. In March, 1871, Capt. R. H. Stotherd completed his tenure ot appointment in the Telegraph School, but remained at Chatham in charge of submarine mining experiments, and as a member of the R.E. Committee.

He was succeeded by Capt. E. D. Malcolm, who had spent the previous year in going through courses of telegraphy and submarine mining. The title of the appointment was very shortly after changed from Superintendent of Schools to that of Instructor in Telegraphy. This branch was then the maid-of-all-work of the S.M.E., its duties including telegraphy, signalling, demolitions, submarine mining, photography, chemistry, and (later) barrack record plans !

The staff was at the same time reorganized, Lieut. R. Y. Armstrong taking up the new appointment of Assistant Instructor in Submarine

Mining, while a few months later Lieut. S. Anderson was replaced by Lieut. W. de W. Abney. Capt. F. A. Le Mesurier was at that time in charge of the signalling branch.

In April, 1871, a few weeks after Capt. Malcolm took office, the first submarine mining company was formed, the 4th Company, which had just arrived at Chatham from Bermuda, being selected for conversion. The strength of the company was 93 N.C.O.'s and men organized in three sections.

The first officers with the new company were Capt. G. Stockley and Lieut. R. G. Scott, while Lieuts. G. Barker, C. M. Watson, and H. St. G. Ord joined later in the year.

The men were carefully picked by Capt. Stockley, and no less than six of them afterwards received commissions.

This company was at once employed on experimental work for the Torpedo Committee at Gillingham.

At that time the actual submarine mining was done on an old corvette called the *Volta*, but this proving insufficient to accommodate all the classes, it was decided to obtain one of the old line-of-battle-ships, then lying at Sheerness, to convert into a barrack and school, and on the 6th January, 1872, the *Hood*, an 80-gun ship, was selected for the work. It took some time to fit up the ship, but she was ready in 1873, and for the next 10 years was a prominent object in the river Medway off Gillingham. Round her gradually clustered a group of lighters, launches, and other boats.

Towards the end of 1871 a detachment of the 4th Company, under Lieut. Scott, was sent to Woolwich to receive the stores, which were beginning to come in in large quantities, having been purchased out of a special vote of credit of £100,000.

In January, 1872, this staff was increased by 40 men, under Lieut. **1872.**
Watson, who relieved Lieut. Scott, and who for the next two years was busily employed in receiving and inspecting the various submarine mining stores which were being purchased. Although patterns were more or less fixed by the Torpedo Committee, there were no regular specifications or methods of test, and all such matters had to be settled, storehouses fitted up, and testing rooms arranged. Stores had also to be packed and shipped for home and foreign stations. By the end of 1872 about 1,800 mines had been purchased. The department was gradually extended to include other R.E. stores such as telegraph and balloon equipment, and was the beginning of the successful inspection branch still existing at Woolwich under the Inspector of R.E. Stores.

In 1872 a detachment was sent to Sheerness for experiments, and a minefield was laid out; and later in the year a regular system of mines was laid down off Hoo and Darnet Forts by Lieuts. G. Barker and Ord, under the supervision of Capt. Stockley, and was kept out till 1873 in spite of the protest of the local skippers.

1873. In 1873 the first dispersal of the little group of submarine miners took place, the 3rd Section of the 4th Company, under Lieut. R. G. Scott, being ordered to Gosport in March, to undertake experiments, while in May the 2nd Section, under Lieut. G. Barker, with W. St. G. Ord, embarked with stores for Bermuda and Halifax, where they started S.M. establishments at both places. This left room at Chatham for another company, and the 33rd Company, commanded by Capt. Parnell, was detailed for submarine mining work.

A class of officers was also selected for training, and posted to the 4th Company, the first class consisting of Lieuts. Addison, Chermside, Bennett, Renny-Tailyour, and O'Brien.

On the 18th August, 1873, the Headquarters, 4th Company, and the 33rd Company marched down to Gillingham and took possession of the *Hood*. Towards the end of this year the 2nd Section of the 33rd Company, under Lieut. Whitmore, went out to Malta with submarine mining stores, and started a submarine mining defence at that station.

In April, 1873, Lieut.-Colonel Nugent was appointed to the newly made post of Assistant Director of Works, and resigned his connection with the Torpedo Committee. Lieut.-Colonel Stotherd, who had received his promotion in August, 1872, was moved to the War Office, and succeeded Lieut.-Colonel Nugent in charge of the submarine mining work, and as President of the Committee. The latter was reconstituted, with Lieut. Hall, R.N., Mr. F. A. Abel, Major Malcolm, and Capt. Armstrong as members, and Lieut. J. T. Bucknill as Secretary.

Lieut. Bucknill had been specially brought home from Bermuda for this duty, and was given an official position under the title of Assistant Secretary, R.E. Committee.

Experiments were at this time carried out at two centres—at Chatham, under Major Malcolm and Capt. Armstrong, and at Gosport, under R. G. Scott and (later) Major Stockley.

The reports of such committees begin now to get somewhat voluminous, and detailed reference to improvements in stores will be deferred to a later chapter.

Experiments with a magneto-electric machine for producing electric light were tried as early as 1871, but as an engine of three horse-power was sufficient to drive it, it is not surprising that the Committee reported that it was of insufficient power.

But the great work done during this period was the *Oberon* experiments, the first of their kind carried out by any Government against iron ships, and even to this day one of the main authorities in determining the necessary strength of iron and steel vessels to resist mines and torpedoes.

The formation of this Committee was primarily the work ot

Colonel W. D. Jervois, who had taken the greatest interest in submarine mining from its commencement, and had probably assisted Sir John Burgoyne in the preparation of his memorandum in 1862.

Jervois had joined the Staff at Headquarters in 1856 as Assistant Inspector-General of Fortifications, and had been Secretary to the Royal Commission appointed in 1859 to enquire into the state of the fortifications then existing, an enquiry which resulted in the expenditure of some 6 millions on defensive works at our more important ports. To the same officer, appointed Deputy Director of Works in 1862, fell the labour of organizing the expenditure of this sum, and he remained at the War Office till 1875, when he was appointed Governor of the Straits Settlements. To his initiative was due the formation of the Obstructions Committee, and their reports passed through his hands. He soon saw the necessity of experimenting against iron ships and, after the Admiralty had refused to assist in 1868, was indefatigable in keeping the question open, and finally succeeded in carrying his point, an iron ship being obtained and money voted for the experiments.

It was originally intended that these experiments should be carried out under the War Office Torpedo Committee (Lieut.-Colonel Nugent), but the Admiralty had at last been roused to appreciate the importance of this question, and wrote in June, 1873, to suggest that the experiments should be carried out by the joint Naval and Military Torpedo Committees, under the supervision of Colonel Jervois. This was accepted in principle by the War Office, and the Committee was finally composed as under :—

President.—	Colonel W. D. Jervois, C.B.	
Members.—	Capt. M. Singer, R.N. Comdr. Hector B. Stewart, R.N. Lieut. W. H. Hall, R.N.	Representing Admiralty.
	Lieut.-Colonel Stotherd, R.E. F. A. Abel, Esq., F.R.S. Lieut. J. T. Bucknill, R.E., also to act as Secretary.	Representing War Office.

Commander H. B. Stewart, R.N., was withdrawn on the 30th December, 1873, and not replaced, and Colonel Jervois himself on appointment to the Straits Settlements was replaced by Colonel T. L. J. Gallwey on the 6th March, 1875. The remaining officers sat throughout the proceedings and signed the final report.

The ship selected as a target for these experiments was an iron paddle-wheel sloop of 950 tons, length 164′, beam $28\frac{1}{2}$′, draught of water 11′. She was fitted with an outer skin, forming a double bottom, constructed as far as possible to resemble that of the *Hercules*, then one of the strongest ships in our Navy. The Committee spent some months supervising various fittings and alterations, and among others a surface condenser was fitted, but there were no engines or boilers on board during the trials. The experiments took place off Fort Monckton, Gosport.

Different series of experiments were carried out with large charges (500 lbs. guncotton) and with small charges (100 to 25 lbs.), each series commencing at some distance which was thought would be safe, and working gradually nearer. Trials were also made with net defence.

It had been intended to fit some armour plates to the *Oberon*, but the results of trials of this nature, made at Copenhagen early in 1875 by a joint committee of Norwegian, Danish, and Swedish officers, were placed at the disposal of the Committee, and enabled them fairly to forecast the probable effects against armour plates.

The detailed results of these experiments are referred to later, but two important conclusions arrived at by the Committee may be mentioned here. First, the importance of subdividing a ship into numerous water-tight compartments and of adding longitudinal water-tight bulkheads between the sides and the boiler and engines; and, secondly, the necessity of firing a charge in close proximity to the side of a ship. This latter requirement led the Committee to advocate a more extensive use of contact mines, which are actually fired by the action of the ships in striking against them, as compared with observation, which are liable to error of the observer, especially in tidal waters.

It is noteworthy that during all these experiments some sheep and rabbits were kept on board the *Oberon* without suffering any injury. In one experiment—100-lb. charge at 25′ distance—Lieut. Bucknill himself remained on board, with the result of a sharp jar on the ankle bones.

"Crusher Gauges," from which great things were expected, were extensively used to measure the force of the explosions, but proved quite unreliable.

The first experiment against the *Oberon* took place on the 6th August, 1874, and the last on 12th June, 1876.

1874. Meanwhile there had been some further changes of units and *personnel*. In March, 1874, the 28th Company, just returned from Ashantee, was converted into a Submarine Mining Company under Lieut. F. W. Heneage, and for the next two years was used as the depôt company on the *Hood*.

In August, 1874, Major Stockley, commanding 4th Company, was moved to Portsmouth to supervise the work connected with the *Oberon* experiments, leaving the Headquarters Section at Chatham under Renny-Tailyour.

In October, 1874, Lieut. D. O'Brien went to Woolwich in relief of C. M. Watson, who left the Submarine Mining Service on proceeding to Egypt to work under Gordon.

In April, 1875, Capt. J. Ramsay was transferred from the 22nd (Telegraph) Company on promotion and took up the command of the 4th Company at Chatham, and in the same month the section from Portsmouth, under Lieut. Scott, rejoined Headquarters.

In June the Company went to Sheerness for a "practice," which on this occasion consisted of work with a detachment from the Navy, the seamen laying the mines and handling the boats, and the Sappers connecting up and doing the electrical work. The Company returned to Chatham for the winter, proceeding to Sheerness again for the summer of 1876.

In April, 1875, the Headquarters and Nos. 1 and 2 Sections of the **1875.** 33rd Company proceeded to Portsmouth for experimental work with the *Oberon*, where a section, under Lieut. H. Chermside, did a combined practice with the Navy similar to that at Sheerness. Early in 1876 No. 2 Section, under Lieut. G. W. Addison, was moved to Malta in relief of No. 3 Section, under Lieut. M. D. Whitmore, and in July, 1876, on the conclusion of the *Oberon* experiments, the Headquarters and No. 1 Section, still under Capt. G. M. Collings, were moved to Devonport, and the 3rd Section, under Whitmore, to Cork Harbour. At the same time the Headquarters of the 28th Company, under Capt. Heneage, moved to Gosport, leaving one section at Chatham under Lieut. R. M. Ruck.

At Chatham, in December, 1875, Capt. W. de W. Abney, who had contributed very materially by photographs and calculations to the discussion of the proper strength of submarine charges, had his title changed to Assistant Instructor in Chemistry, and was succeeded temporarily in the Telegraph School by Lieut. R. G. Scott.

In January, 1876, Lieut. G. Barker returned from Bermuda and was **1876.** ordered to Woolwich as Inspector of Stores, to replace O'Brien, who had been appointed Assistant Director of Works at Woolwich.

On the 1st April, 1876, Major Malcolm completed five years' tenure of his appointment at the Telegraph School, and was succeeded as Instructor by Capt. Armstrong, who was himself replaced as Assistant Instructor by Lieut. Bucknill.

In October, 1876, an important change was made at the War Office. Lieut.-Colonel Stotherd was ordered abroad, and exchanging, was moved to Belfast, and thus severed his connection with submarine mining, for which he had worked so well for 10 years. He will probably be best remembered as the author of the first textbook, but his work as a pioneer proved to be on thoroughly sound lines, and he deserves to be recorded among the "heroes" of the Mining Service.*

* R. H. Stotherd was born at Tyrone in 1828, and received his first commission in 1847. He served at Gibraltar 1849-1853, on the Survey in the South of England 1853 to 1861, during which he surveyed the site of Aldershot Camp, and was in Canada from 1861 till he became an

He was succeeded at the War Office in October, 1876, by Lieut.-Colonel W. Crossman, who had been intimately connected for many years with the improvements in our defences, and had been Assistant Director of Works since August, 1875. Crossman was given the title of Inspector of Submarine Defences, and recognition was thus given to an office which endured for nearly 30 years.

Capt. S. Anderson, who since leaving the Telegraph School in 1871 had been employed as Chief Astronomer with the Canadian Boundary Commission of 1872, was brought into the War Office as Assistant Inspector of Submarine Defences under Crossman, and the staff of the office was completed in July, 1877, by Lieut. Bucknill, who moved from Chatham to the War Office, and carried out from there the inspectional duties at Woolwich. Lieut. G. Barker, from Woolwich, succeeded Lieut. Bucknill as Assistant Instructor for Submarine Mining at Chatham.

In addition to the regular instructors, several officers had from time to time been employed as Temporary Assistant Instructors. Lieut. Renny-Tailyour was so employed on the *Hood* from 1875 to 1877, and Lieut. Scott was in the Telegraph School from December, 1875, to December, 1876. On this latter date Lieut. Scott was appointed Assistant Instructor in Telegraphy. At the same time the Assistant Instructor in Signalling was withdrawn, and signalling became the business of the Army as a whole instead of a speciality of the Royal Engineers. The genesis of the present Army signalling is really due very largely to Capt. Malcolm. Prior to his arrival at Chatham the system of signalling had been dependent on a code book, a necessarily slow method and of doubtful accuracy. Malcolm conceived the idea of spelling out the words in the same way as the telegraphists were doing. His views were supported by the Commandant, Colonel Gallwey, and the new method was finally adopted. The first use made of this system was by the submarine miners, who, being many of them telegraphists, used to flag messages in Morse code across the water at Gillingham.

The year 1876 saw the end of the labours of the Torpedo Committee, and henceforward all the work of experiment as well as sealing of stores was carried on by the R.E. Committee, of which

Instructor at the S.M.E. in 1866. On leaving the S.M. Service he was C.R.E., Belfast, 1876 to 1881, in charge of the Irish branch of the Survey 1881 to 1883, and in 1883 succeeded Major-General Cooke as Director-General, Ordnance Survey, at Southampton, receiving the C.B. in 1884. He retired under the age clause in November, 1886, with the honorary rank of Major-General, and died at Camberley in 1895.

On 6th July, 1871, Sir J. Burgoyne wrote to Stotherd: "I am very much obliged to you for the copy of your notes on submarine mines. It is a subject in which I take a particular interest, and I have been glad that the consideration of it has been in such able hands as yours."

Lieut.-Colonel Crossman, I.S.D., was made a member, as well as Capt. Armstrong. But submarine mining remained a distinct branch of the Committee's work, and the annual reports dealing with the submarine mining work were published in a separate series of volumes from those of other branches of engineering. Five years later, in 1881, the electrical work of the R.E. Committee had grown so much that it was necessary to appoint a Secretary with submarine mining experience, and from that date till 1902 the Secretary of this Committee was always selected from the Submarine Mining Service.

In their last report the Torpedo Committee made definite recommendations as to the details of the low-tension fuze, the introduction of the Armstrong wooden relay, and the Mathieson circuit closer, also junction boxes and other details. They also describe some experiments carried out in 1875 at Stokes Bay with various electric lights.

There were also experiments with patterns of iron mine cases in lieu of the wooden jackets, which were found to get water-logged.

The important experiments carried out at Sheerness and Portsmouth in combining Naval and Engineer working parties are also referred to by this Committee. It had long been recognized that the work of submarine mining required two distinct forms of training, one for the electrical work and another for the water work. It will be seen that the electrical apparatus had by now reached a good standard of efficiency, but required careful handling; and this had brought about a rupture between the two services, which up to now had assisted one another with experiments. The R.E. had found by experience that to maintain a minefield in good order it was essential to be able to get fairly accurate tests of the daily condition of mines, so that bad mines could be eliminated, faults could be foreseen, and arrangements made for repairs. The R.N., led by Capt. J. A. Fisher, then in command of the *Excellent*, argued that all you wanted to know was if a mine were likely to fire correctly, and that the power of accurate testing gave no advantage to compensate for the extra complication and weight of stores. They therefore rejected relays and shutter boxes, and introduced a circuit closer with a simple contact.

Probably both sides of the controversy were right, from their own point of view. To the R.E. it was of first importance to have all their mines efficient and to be able to keep them so; questions of storage or time and skill in preparation did not trouble them while their permanent firing stations had ample room for the simple testing instruments required. To the R.N. questions of storage or extra *personnel* are vital, while the conditions under which they would use mines did not presuppose a minefield being kept out for any length of time.

But while the R.E. retained the electrical work, it was not yet decided that they should also carry out the water work. Arrangements were therefore made for combined practices of about 1 officer and 25 men of the R.E. and 1 officer and 50 men of the R.N. at Sheerness and Portsmouth in 1875. At both stations the personal relations between the two services were of the most cordial description, but the naval men were criticized on account of their want of previous training both in the shore and water work of submarine mining and their want of knowledge of signalling. It was also pointed out that the same men would not be available in a subsequent year. Capt. Ramsay, of the 4th Company, recommended that the R.E. should be trained to the boat work and do without the Navy, but Colonel Stotherd, though he agreed that previous training was indispensable, thought that a specially trained body of naval pensioners would best meet the case.

The decision to employ a mixed force of R.E. and R.N. was the outcome of a discussion started by Brigadier-General J. Adye, the Director of Artillery in 1873, as to the status of the Submarine Mining Service. General Adye's minute was practically a request that the Artillery should be allowed to take some part in the work of submarine mining; his suggestions were not very definite and their tendency would have been to place the Submarine Mining Service under a sort of Permanent Commission composed of the I.G.F., D. of A., and Director of Naval Ordnance. In reply Colonel W. Jervois prepared a memorandum dealing very fully with the past history and present position of the Submarine Mining Service, which was endorsed by the I.G.F.—Sir F. Chapman—and was regarded for many years after as finally settling the question that submarine mining should be done by the Engineers.

This question was however constantly recurring, and frequently reappears in later years, generally in remarks by critics with little practical knowledge of the work. The whole controversy is dealt with in Chapter V., where Colonel Jervois' minute is treated at greater length. One result of this correspondence was a conference in 1874 with certain naval officers, when it was decided that the R.E. should do the work connected with the preparation, testing, and firing of the mines, and the Navy should provide the vessels and assist with laying the mines and the water work generally.

The results of the trials of this system in 1875 were not sufficiently satisfactory to justify its continuance, and it was open to the objection that the Navy could not guarantee to provide men for such duties in war time. On the other hand, the large increase to the regular R.E. to provide the necessary water parties could not be justified.

The question of *personnel* was settled two years later by the formation of the Militia Submarine Miners, but the Navy continued to provide and maintain the necessary boats until a much later period.

At the beginning of 1877 the Submarine Mining Companies were thus distributed:— **1877.**

The Headquarters and two sections of the 4th Company were at Chatham under Capt. J. Ramsay, but they proceeded each summer to Sheerness for practice.

The 2nd Section was divided between Bermuda and Halifax under Lieut. Ord.

The Headquarters and two sections of the 28th Company, under Capt. Heneage, were at Portsmouth, with the 3rd Section at Gravesend, under Lieut. Rawson.

The Headquarters and one section of the 33rd Company were at Devonport, under Capt. G. M. Collings; the 2nd Section was at Malta, under Lieut. Addison; the 3rd Section at Cork, under Lieut. Whitmore, but this rejoined Headquarters in April.

In April, 1877, the 23rd Company was converted into a submarine mining company, and stationed at Chatham.

In October, 1877, the Headquarters and two sections of the 4th Company moved from Chatham to Portsmouth, and the following month the 28th Company—Headquarters and two sections—embarked for Bermuda, the officers being Capt. Heneage and Lieuts. Von Donop, C. K. Wood, and H. E. Rawson. The 3rd Section, 28th Company, meanwhile moved from Gravesend to Portsmouth, under Lieut. R. M. Ruck, and the following February moved to Cork Harbour.

In 1877 Capt. Collings was sent to India to organize the submarine mining defences, but his health failing, he was replaced in the following year by Capt. Featherstonhaugh.

In March, 1878, Lieut. R. G. Scott died suddenly in Brompton Barracks, the result of fever contracted some years previously in Mauritius. The first subaltern officer to be posted to a submarine mining company, he had made a study of electricity and contributed in a marked degree to the various electrical developments at the Chatham School.

He was succeeded as Assistant Instructor by Lieut. P. Cardew.

Meanwhile in 1877 a new departure was made by sending all the junior officers at the S.M.E. through a course of submarine mining on the *Hood*, and in this year 22 officers were trained in this subject, several classes being formed of senior officers, among whom were T. Anstey, F. R. de Wolski, and A. T. Preston.

Among junior officers trained in 1877 occur the names of C. Wingfield-Stratford, L. B. Friend, F. Rainsford-Hannay, J. C. Middlemass, M. A. Cameron, H. E. Tyler, and A. E. Wrottesley.

In 1878 there were trained G. D. Pritchard, E. P. Leach, E. J. G. Boyce, V. Caillard, C. Penrose, W. F. Hawkins, J. H. Cowan, G. F. Leverson, G. A. Carr, O. E. Ruck, and others.

At this time considerable difficulty was found at several ports in obtaining permission from the local authorities to carry out mining practice. So the section from Cork and the 33rd Company at Devonport were sent to Pembroke Dock to do their annual practice, the 4th Company practising at Portsmouth and the 23rd Company at Sheerness.

These practices were now becoming a feature of the training; practice reports were regularly rendered, and criticized by the I.S.D., and there was much competition between the various sections.

The object of a "practice" was to rehearse as far as possible the actual work of laying out a minefield. For this purpose plans of a special minefield were prepared, the mines were drawn from store, loaded in dummy, generally with sand or gravel, the apparatus was prepared and tested, the cables cut and firing stations got ready, so that every operation except the actual handling of the guncotton was carefully rehearsed. The minefield was if possible a portion of the real defence, but it was found necessary in any case to arrange to mark it by boundary buoys to prevent damage to the mines by the ordinary traffic. At the conclusion of the practice all stores were cleaned and tested and returned to the charge of the Army Ordnance Department under store conditions. A practice usually lasted about three months.

The value of such an annual training cannot be over-estimated, and these practices did much to promote mutual respect between officers and men, and to contribute to the excellent relations between the commissioned and non-commissioned ranks, which was a marked feature of the Service.

When a few years later the Militia and Volunteer Corps had been formed, it was usual to arrange the annual practice so as to include the period of training of the auxiliaries. The effect of this was that for a certain period each year—seven weeks at naval ports and two weeks at others—the whole submarine mining *personnel* allotted for war were actually present and practising their war duties at each port.

1878. In 1878 submarine mining received the impetus of its second war scare, the Russo-Turkish War of 1877–8 rousing the authorities to the necessity of strengthening our ports abroad.

For this purpose detachments of an officer, with a few men and a quantity of stores, were sent out to various stations and ordered to prepare mine defences.

In June, 1878, L. B. Friend sailed for Hong Kong, and E. H. Rhodes for Singapore.

In July, 1878, R. M. Ruck was ordered to the Cape of Good Hope, but his orders were cancelled at the last moment, on the receipt of adverse reports as to the possibility of mining at that station.

In August, 1878, G. Tower left for Jamaica, F. Rainsford-Hannay for Trincomalee, and H. de H. Haig for Mauritius.

The story of all these places for the next year was much the same. No preparations for storage had been made at the stations, and the mine stores, especially the cable, suffered from the heat and damp. It was necessary also to engage and train natives to do the rougher work, so that some time elapsed before it could be said that the defences were efficient.

In November, 1878, Lieut. M. A. Cameron was ordered to the War Office to prepare an official manual in place of Stotherd's Notes, which were quite out of date, and also, having been made "confidential,"* were very difficult to obtain.

In December, 1878, a further step in advance was made by the formation of the first Corps of Submarine Mining Militia at Portsmouth. This was formed to provide a body of men to carry out the water work of submarine mining in concert with the R.E., and was the forerunner of the splendid group of auxiliary corps which contributed so much to the success of the Service.

Its beginning may be traced to a suggestion by Lieut. C. M. Watson in 1873, who outlined in a memorandum the organization of a submarine mining corps, composed partly of highly trained R.E. for the electrical work and partly of less well-trained Militia for the water work. Many of his proposals were adopted.

Details will be seen in Chapter VIII.

This year (1878) there commenced a noteworthy series of experiments carried out jointly by the R.N. and R.E., which yielded much data as to the best way of attacking and defending a mined area, and had an important effect on the future patterns of mining stores.

For some years previously the Navy, though not developing their mine systems, had given great attention to the methods of clearing a way through minefields, and had evolved three systems, called "creeping," "sweeping," and "countermining." The first consists in dragging an explosive creep or grapnel along the bottom till it catches an obstruction; the creep is then hauled tight and the charge exploded, so that if a cable has been grappled it is cut by the explosion. The objection to this system is that the attack is always uncertain as to which mines are connected to the cut cable, and the number of boats and time required to clear a definite area is considerable. Sweeping is done by two boats with a bight of rope or chain hanging between them. The boats drift slowly over a minefield until the sweep catches a mine, which is then either raised or cut adrift by a charge. This method cannot be carried out under artillery fire, and is ineffective against ground mines; it is also very slow.

* This step was not taken till after the Notes had been printed and published in New York.

The third method, countermining, is the most effective of all, but requires considerable preparation and a large expenditure of stores. It consists in firing in a mined area a series of large charges, designed to damage or destroy all defensive mines within a certain radius.

Countermines usually contained 500 lbs. of guncotton, and were exploded at distances of 60 yards apart, this having been found by experiment to ensure the destruction of all mines lying between any two countermines. To obtain rapidity of laying, they were arranged in rows of 12 with buoys marking the ends of the cleared channel. The width cleared by a row of this size was only 60 yards, so that to get room to bring up a big ship it was necessary to lay two rows of countermines side by side and exactly 60 yards apart. This requirement was a most difficult one, but the difficulties were vigorously tackled by the Navy, and though the problem of obtaining accurate alignment was never really solved, the operations of preparing and laying the countermines were brought somewhere near perfection, and the attack in the various operations used to develop with a rapidity which proved very trying to the defenders.

To enable the R.E. to study these different methods of attack, combined operations were arranged in September, 1878, off Fort Monckton, Gosport. The defended channel was 800 yards broad and 800 yards deep, defended by 22 observation and 20 E.C. mines. The latter were set about 7′ below the surface, and thus would not be effective against light countermining vessels. A row of buoys supporting a wire rope was placed at the front of the minefield. The mines were laid by the 4th Company, under Capt. J. Ramsay, R.E. The miner was used as a guard boat. The attack comprised two steam launches, two steam pinnaces, several dinghies with creeps, and two gunboats towing launches with countermines.

The operations took place in daylight, commenced at 2.9 p.m. and were finished by 2.20 p.m., by which time the attack claimed to have laid their countermines and the defence to have sunk all the attacking vessels ! This was the usual end of such operations, and the weighing of contending claims often provided most troublesome problems for the umpires. Of the mines, two observation mines were fired at the countermining boats, and the blowing charges exploded. The wire rope obstruction proved useless, as it had been insufficiently buoyed, and Capt. Ramsay strongly recommended a boom to arrest the progress of the countermining vessels, also the laying down of large chains to counteract creeping.

Following these operations, experiments were carried out at Portsmouth, Sheerness, and Pembroke during the annual practices to determine the effect of the explosion of a countermine on mines at various distances. These gave most valuable data as to the relative strength of the mining gear, and led eventually to the strengthening of mine cases and apparatus.

The operations at Fort Monckton were repeated in 1879, but on 1879.
this occasion they were carried out at night. The minefield was arranged with a friendly channel defended by observation mines on the line of mines system. The cables were well protected by old chain, etc., and only one was cut during the operations.

There was a boom of baulks laid end to end, also net entanglements and others. Electric lights were employed on both sides for the first time in such operations.

Naval boats were employed as guard boats.

The attack included nine steamboats and smaller boats. The operations of the Defence were under Colonel H. Schaw, R.E.; those of the Attack under Capt. Gordon, R.N., of H.M.S. *Vernon*.

The chief umpires were Colonel G. Graham, V.C., C.B., R.E., and Capt. Herbert, R.N., and under them there were a large number of assistant umpires.

The operations began at 9 p.m. and lasted one hour. They commenced with a rush to the boom by two steamboats with charges which were successfully fired, making a gap 100′ wide. These boats were not seen or fired on.

The countermining operations failed, only one-quarter of the proper number of charges being fired. On the other hand, the defence helped the attack by firing their lines of mines at small boats and thus clearing the channel.

The E.C. mines worked well, and of five fired, two were adjudged to have sunk steam vessels. One vessel was adjudged sunk by a mechanical mine.

The boom was easily overridden by the attacking vessels, which were fitted with spars for jumping, but the nets formed a good obstruction, nearly every steamboat in the attack getting foul of them.

The electric lights proved effective as the weather was favourable, and owing to the serious illness of an officer in the neighbouring hospital no guns were fired.

One gunboat, one countermine boat, and five out of the six launches were ruled out of action by gun fire.

The third of this series of experiments took place in 1880 under 1880.
arrangements which were very similar to those of the previous year. The minefield had however been more completely covered by mines, and there were several rows of obstructions, including a ladder boom of baulks, 12″ square and 9 to 10′ long. There were 20 boat mines in front of the boom, each supposed to contain 20 lbs. of guncotton. Colonel Schaw, R.E., and Capt. Gordon, R.N., again commanded the opposing sides.

The attacking flotilla consisted of H.M.S. *Glatton*, 3 gunboats, and 30 other vessels and boats.

The operations took place by daylight and lasted about an hour and a-half. In the result the umpires were of opinion that the countermines had failed to clear a channel through the defences, and this although no countermine boats had been put out of action and the attack had the advantage of daylight and absence of real shot or shell. Of 24 creeps exploded, one cut a cable which happened to have a considerable number of mines on it. Of the attacking boats, half were ruled out of action. The umpires were unanimously of opinion that such attacks could not be undertaken by daylight under service conditions.

These operations were followed by some very instructive experiments at night to test the effect of smoke on the electric light.

For these the attack advanced on the minefield in much the same order as in daytime.

The night was calm and still, and the effect was that the smoke from the defence guns after two or three rounds entirely hid the attacking boats from view!

To remedy this Colonel Schaw proposed the use of smokeless powder, a wish which was not realized for 12 or 13 years. The umpire's remedy was the employment of armed guard boats by the defence to observe the minefield at close range, an opinion which had great effect on subsequent experiments of this description.

1879. The distribution of companies in 1879 was practically the same as in the previous year, the only moves being those prior to the practices at Sheerness, Portsmouth, and Pembroke.

There was also a demand for R.E. officers in the East of Europe to assist in the work of settlement of boundaries arising from the Russo-Turkish War, and a special commission was sent out under Major and Brevet Lieut.-Colonel C. W. Wilson, R.E. Of the half-dozen officers who accompanied him, four were drawn from the Submarine Mining Service—S. Anderson, F. R. de Wolski, H. C. Chermside, and Vincent Caillard.

At the same time—April, 1879—Capt. M. T. Sale, the Secretary of the R.E. Committee, was lent for similar service, and Lieut. G. Barker became Acting Secretary, vice Sale, and was himself replaced temporarily as Assistant Instructor by Lieut. H. W. Renny-Tailyour.

In the middle of the year an important step was taken by the formation of a special Committee on Electric Light Stores, with Lieut. G. A. Carr as Secretary.

This Committee sat till early in 1880, and from their deliberations emerged the first complete electric-lighting plant—D. Gramme, with Mangin Projector and inclined lamp.

1880. The distribution of companies at the beginning of 1880 was the same as in the previous year, the units at home assembling for training at Sheerness, Portsmouth, and Pembroke. Abroad the three small detachments at Hong Kong, Ceylon, and Singapore were assembled for a practice at the last-named place under Lieut. E. F. Rhodes, where they remained about three or four months. This was repeated in subsequent years.

The only officers whose training was recorded in 1879 were E. C. T. Hawker and F. R. Reynolds, but in 1880 there came the names of H. A. L. Paterson, H. N. Dumbleton, P. R. Burn-Murdoch, and E. Druitt.

In June, 1880, the first Manual of Submarine Mining was issued from the War Office. This had been prepared in the office of the I.S.D. by Lieut. M. A. Cameron. It is interesting to see how far the science of submarine mining had progressed by this time. Of mine cases, the cylindrical observation mines had all been introduced, but the latest pattern of E.C. mine was the pear-shaped Mark IV. Wooden jackets were still used as circuit closers, and the old C.C. apparatus with stiff spindle was still fitted in these; but for the pear-shaped mines there was the much improved Mark IV., with Mathieson's C.C. with coiled spring and the Armstrong wooden relay for testing.

E.C. mines were connected in groups, which were just being reduced from eight to four, and disconnecting fuzes were in use.

The Leclanche battery was used for firing, and Daniells for signalling, but not quite in the modern form.

Cables had not made any great advance on the patterns of 10 years previously, and opinion was divided on the merits of india-rubber or gutta-percha insulation. Joints were always soldered.

A typical stores establishment had been gradually evolved, and is given in the manual, including pier with cranes, connecting-up ground, cable tanks, stores, workshops, and boathouse.

Typical test rooms and observing stations also appear, the latter using double observation firing. The vessels and boats which had been evolved included the *Miner* class, 42′ launch and lighters, cutters, etc. Mines were always slung alongside the pier head or lighter, and laid with lowering line and special hook.

But the greatest novelty in this Manual was the Shutter Board, designed by Lieut. G. A. Carr. As early as 1873 it was customary to fix all firing and testing instruments on a table, on which the various points were identified by a system of letters. Shutter boxes were also in use, but were placed on the edge of the test table, and all the connections with cables were made at the time the minefield was laid out. Great care was taken to make everything as neat and tidy as possible, but there was obviously some risk of a mistaken connection.

With the increased size of minefields it was necessary to employ an increased number of shutters, and the number of cables, etc., increased in proportion.

The first step was to fix the shutter boxes on shelves on the wall above the test table, and other important additions followed. The firing arrangements—firing keys and earths—were removed from the test table to a separate small table of their own, and the firing and other batteries were provided with stands, placed round the room, with leads fastened round the wall to connect them as required. To preserve the shutter boxes from the jar of gun fire or mine explosion, they with their brackets were mounted on a boarded surface called the "shutter board," about 12′ long by 4′ high, which was supported on solid vertical timbers a few inches from the wall.

One feature of the arrangement was that all connections were made on the front of the board so as to be clearly visible.

To assist in tracing circuits, the leads were coloured to indicate their use, and the identification letters painted on the board. Boards of instructions were printed and hung up in the test room.

Telephones were employed in connection with the system of testing.*

In the Manual all these arrangements were stereotyped into a definite pattern, which could be reproduced at any station, and a few years later it became customary to make up shutter boards with leads and terminals complete at Chatham and despatch them for use all over the world. By this method testers found, in every firing station they entered, batteries and apparatus arranged exactly as those whose position they had already learnt by heart during their early training.

Successful as this innovation was, it was not installed without a good deal of criticism. The submarine miners of the old school supported the naval view that it was an unnecessary refinement, while the large majority of the general public, who in those days received no electrical training at all, if they were admitted to a test room, gazed in awe at the bright brass terminals and coloured leads, as if the whole were some uncanny monster.

But, in fact, the arrangements of the test room, and indeed all the tests used by the submarine miners, were, in the light of our modern experience, extremely simple. Compare for instance a telephone exchange board or the switchboard of a power station in one of our smaller towns with their systems of records and tests, and the test room with all its forms and tests becomes insignificant.

The main merits of the arrangement—apart from the fact of its evolution so early in the history of electricity—lay in its reduction of the operation of testing to a mathematical certainty and its capacity for rapid work. The latter became very important later on when rapid mine laying was introduced, and tests had to be taken for two or three hours at a time at the rate of 80 to 100 an hour.

* One of the first telephones introduced into England was used by Lieut. R. M. Ruck at Cork and Pembroke Dock in 1877–78.

In December, 1880, Capt. J. Ramsay retired from the Service, and the command of the 4th Company passed for a time to Capt. de Wolski.

Capt. Ramsay had been connected with the Submarine Mining Service since 1875, and had contributed materially to the progress which was made in this period. His most important piece of work was the experiments at Fort Monckton already referred to.

In 1881 there were several changes among the *personnel* of the Submarine Mining Service. **1881.**

In February Lieut. G. Barker was appointed Secretary of the R.E. Committee, and was succeeded as Assistant Instructor in Submarine Mining by Lieut. R. M. Ruck.

In June, Colonel W. Crossman was succeeded as Inspector of Submarine Defences by his Assistant, Major S. Anderson, but the latter officer, who had been for some time in indifferent health, died suddenly in Scotland in September, 1881.* The appointment at Headquarters was left vacant till the beginning of the next year, Capt. J. T. Bucknill acting as I.S.D.

In June, 1881, Qr.-Mr. and Hon. Lieut. McCulloch joined the Submarine Mining Service for charge of stores on the *Hood* and at Gillingham.

In December, 1881, the S.M.E. was inspected by Mr. Childers, Secretary of State for War, who visited the *Hood* and the new test rooms in Hoo and Darnet Forts, and was much interested in the progress made in submarine mining.

In January, 1882, the 4th Company, under Capt. A. C. Alexander, with Lieuts. F. R. Reynolds and H. A. L. Paterson, was ordered to Bermuda in relief of the 28th Company, ordered home to Portmouth. **1882.**

Capt. Heneage having died at New York in October, 1881, the 28th Company was brought home by Lieut. C. Penrose.

In February, 1882, the Submarine Mining Branch at the War Office was rearranged, Lieut.-Colonel S. D. Malcolm becoming I.S.D., and Lieut. E. F. Rhodes taking over the duties of Inspector of Stores from Capt. Bucknill.

The latter officer became Executive Officer for Submarine Mining at Gosport.

On 1st April, 1882, the 23rd Company at Chatham was converted into the Submarine Mining Depôt, and took over the detachments at Hong Kong, Singapore, Ceylon, Mauritius, and Jamaica. To replace it as the Defence Company at Sheerness and Chatham, the

* Major S. Anderson, though he had not seen any active service, had a distinguished record in several branches of Engineering. Born in 1839, he was commissioned in December, 1858, and from September, 1859, to 1862 was employed as a surveyor with the North-American Boundary Commission at Vancouver, British Columbia. From 1872–74 he was again employed in similar work as Chief Astronomer to the British Commission on the frontier west of Lake of the Woods. For these services he was made a C.M.G. in 1877.

27th Company was on the same date converted into a Submarine Mining Company at Chatham, under Lieut. C. C. Carter, who had just returned from Halifax.

In June, 1882, Sir T. Gallwey, who had continued at the War Office to take great interest in the work, vacated the post of I.G.F. on being appointed Governor of Bermuda, and was succeeded by Sir A. Clarke. The latter was then only a colonel, and was selected by Mr. Childers over the heads of several senior officers. This is no place to show how he justified the selection, but except perhaps Colonel Jervois, no officer in high position did more to bring to notice the valuable services which were performed by the Royal Engineers. Under Sir A. Clarke's supervision every branch of Military Engineering was improved and developed, and it is natural that among others the Submarine Mining Service received its share of attention. How this affected its expansion will appear in the next chapter.

1883. Meanwhile a few more stages may be chronicled. The officers trained during 1881 included D. A. Mills, A. M. Stuart, W. S. Vidal, L. Quill, and L. J. Dopping-Hepenstal, and in 1882, F. V. Jeffreys, H. B. Roberts, A. Grant, and M. A. Boyd. No officers were trained in 1883.

On 15th January, 1883, Major Armstrong vacated his appointment at the S.M.E. for special duty under the Board of Trade in connection with electric lighting, where he laid the foundation of the regulations which make that branch one of the most efficient of the Government departments. He was succeeded as Instructor in Telegraphy by Capt. P. Cardew, who was replaced as Assistant Instructor by Lieut. G. A. Carr.

In May, 1883, a very important change was made by the abandonment of the *Hood* and the transfer of the officers and men to St. Mary's Barracks. The companies affected were the 23rd, under Capt. A. T. Preston, and the 27th, under Lieut. L. B. Friend.

For some time the *Hood* had been found too small for the number of officers and men to be trained, while the conditions of work did not lend themselves to the accuracy and cleanliness which should be the life of all electrical work. A piece of ground had therefore been obtained near Gillingham Pier, on which buildings were gradually erected, first for the electrical work and then for other purposes. This was carried out under the supervision of Lieut. R. M. Ruck, who was ably seconded by Lieut. and Qr.-Mr. A. N. McCulloch. Once it was necessary to land parties for work, the advantages of a floating home disappeared, and left only the discomforts of cramped accommodation and badly kept surroundings.

A little time before this the garrison of Chatham had been reduced and St. Mary's Barracks vacated by the infantry. These were now handed over to the R.E., and the Submarine Miners were moved into them in May, 1883.

With this move begins a new period of existence for the Submarine Mining Service, which will form the subject of the next chapter.

Although no actual steps had been taken up to this date to provide a submarine mine defence at the commercial ports, it may be convenient to summarize here the interchange of views between the Admiralty and the War Office on the subject.

In August, 1870, the Defence Committee, which included several of the senior officers at the War Office and the Admiralty, issued a memorandum on the defence of our commercial ports. Sir Sydney Dacres and Capt. A. W. Hood, Director of Naval Ordnance, were the naval members of this Committee.

In this report they state :—

"The security of our principal commercial ports is of so much moment to the trading interests of the country . . . that it is of the utmost importance that measures should be taken for the protection of the shipping, etc.

"The ports referred to are Mersey, Tyne, Humber, Falmouth, Holyhead, Clyde, Belfast, Dublin, The Shannon, The Forth, for which mines for the obstruction of the rivers should be provided, to supplement the batteries. The Committee desire to reiterate the opinion expressed on previous occasions that mines are a most imporant element of harbour defence."

In 1877 the Defence Committee, of which the naval members were Rear-Admiral Hood, Admiral Sir Hastings Yelverton, G.C.B., and Rear-Admiral Boys, urged strongly the necessity of making provision for all works for the defence of commercial harbours, including £150,000 for submarine defences.

In 1880 a Committee was appointed, under the presidency of Lord Morley, to consider the defences of the commercial ports. The members were :—Vice-Admirals Phillimore and Boys, representing Admiralty ; Lieut.-General Sir G. Wolseley and Sir F. A. Campbell, representing War Office ; Sir Digby Murray, the Board of Trade ; C. J. Knyvett, Esq., the Home Office.

They appointed Sub-Committees to visit the various ports, who at most places recommended the use of mines.

In the final report they say :—

"Submarine mines, again, are of the greatest use in closing the entrance to rivers and narrow harbours such as the Tyne, Upper Humber, Tay. In the Forth, Clyde, and the Mersey, though less effective as a means of defence, they can be used with advantage to block subordinate channels and to narrow the main ship channels.

"The Committee are strongly of opinion that no more time should be lost in setting on foot Submarine Mining Establishments at the following localities :—Humber, Tyne, Forth, Tay, Clyde, Mersey, Falmouth, Belfast, Dublin."

This report was accepted by the Defence Committee and by the Admiralty and War Office.

The action taken as a result of this Committee will be seen in the next chapter.

CHAPTER III.

HISTORICAL.—MINES IN THE BRITISH ARMY.—3RD PERIOD—1883–1892.—VIGOROUS MANHOOD.

IF the 12 years dealt with in the last chapter may be considered as the childhood of the Submarine Mining Service, the period from 1883 to 1892 may be described as that of vigorous manhood.

Up to 1881 the development of stores and patterns had proceeded on well-defined lines of experiment, but the organization of the *personnel* had not advanced concurrently, though no doubt the question had been constantly considered by the officers responsible for the service. Indeed, Sir F. Chapman's Committee of 1871 had made special reference to this aspect of the problem.

It was evident that the first step should be to train officers and men to form a nucleus of the future organization, and that, until a sufficient number had been trained, it was useless to discuss other details. The early organization thus followed that of the rest of the Engineers of that period, the *personnel* being organized in companies of a strength of 3 officers and 93 N.C.O.'s and men, each divided into 3 sections.

Up to 1881 five such companies had been formed, but as a submarine mining defence had been provided at 10 stations, with many more in prospect, it had been necessary to treat the section rather than the company as the working unit, and sections were frequently detached from their headquarters and kept for years permanently separated from them. They were usually commanded by subalterns, but had no proper company staff, while the rendering of returns and states to company headquarters must have involved much unnecessary correspondence.

In this chapter we shall see how this organization gradually developed, till, in 1892, the number of submarine mining stations had increased to 26, at each of which there was a Regular unit with complete internal organization, and with an establishment which was gradually being adapted to the actual requirements of the defence. There was also at each station an organized auxiliary force of Militia, Volunteers, or locally enlisted natives.

It will also be seen how concurrently with this organization there was being developed a very complete system of preparation of the defence stores, so that the work on the outbreak of war was reduced to a minimum, and a system of training so complete that practically every port in the Empire could have some defence by mines within a few hours of the order to lay out the defences.

During the period dealt with in this chapter the War Office organization was strengthened and extended, and a complete system of inspection built up under Malcolm, Armstrong, R. M. Ruck, and Penrose; the school at Chatham increased fourfold under Preston, Carr, Dumbleton, and Reynolds, while at the same time an auxiliary school was developed at Gosport for training in rough and deep water.

A very important addition to the defences was made in this period by the experimental growth and purchase of the Brennan torpedo, in connection with which L. B. Friend, the Secretary, R.E. Committee, and Major M. T. Sale did much useful work.

The position of the submarine mining defence at this time cannot be better described than by some extracts from a confidential memorandum prepared by Sir Andrew Clarke, and dated 16th April, 1885. It also shows the genesis of the new organization which was being gradually developed :—

"In a matter of such importance as the condition of our submarine mining defences, which practically are (with the fleet) a first line of defence, and which, from their nature, give little evidence of their existence, I have thought it advisable to prepare an exact statement of their condition, which may be at once reassuring to the country, and should it be disclosed abroad, will be evidence of our determination to be ready in this respect.

"I will preface this statement by a short account of the steps which led up to our present organization, which may be of use for reference and guidance.

"On assuming charge, in the spring of 1881, of the School of Military Engineering, Chatham, to which are attached the Electrical and Submarine Mining Schools, I had naturally to study the then existing condition and organization of this arm of the national defence.

"I found, when going into the matter with the aid of those officers of experience who were at the station, that our weaker points were :—

(1). The insufficiency of the *personnel* to provide for the defence of the military ports, considering the tendency of modern warfare to decide its issue by quick and heavy blows.

(2). The necessity for an elasticity in the organization which would admit of the defence of the country as a whole.

(3). The necessity for the revision of existing plans of defence so as to be in accord with the experience gained at that date, and the preparation of plans for those ports for which they had not already been designed.

"I therefore, with the assistance of the officers referred to, viz., Major Armstrong, Major Barker, Capt. Ruck, and Lieut. Carr, prepared my memorandum of 20th August, 1881, which gave a complete and detailed scheme for the defence of the whole Empire. Of course, many of the details were in practice or had been previously suggested, but no scheme as a whole was in existence.

"On assuming my present duties in 1882, my efforts for the improvement of our submarine mining defence were, by the express direction of the then Secretary of State for War, made in the direction indicated in that memorandum.

"Measures were taken for the preparation of projects of defences mutually agreed upon by the responsible chiefs of the military and naval services for the various waters, and interchange of idea has also been arranged between the responsible Artillery and Engineer officers as regards the special armaments required for the protection of the mine-fields.

"The next step was to obtain the approval of the addition of three companies to the strength of the Royal Engineers employed on these duties, and two Militia companies.

"Later on an experiment was made, initiated by and with the liberal assistance of Colonel Palmer, M.P., commanding the 1st Newcastle and Durham Engineer Volunteers, in which the feasibility of employing our Volunteer organization in the way proposed was demonstrated.

"This was still further tested subsequently with the 1st Lancashire Engineer Volunteers, under Colonel Rigby, and the 1st Lanarkshire Engineer Volunteers, under Colonel Matheson, C.B.

"My proposals of 1881 having been re-cast with the light of present experience, the following organization, on the recommendation of H.R.H. the Commander-in-Chief, has been approved by the Secretary of State for War:—

"For the defence of our military ports at home, and of Malta, Bermuda, and Halifax abroad:—

10 companies, Royal Engineers (including a depôt), and 4 companies of the Southern Submarine Mining Militia.

"For the commercial harbours:—

The nucleus of an expansive organization consisting of 4 companies of Volunteer Engineers and 1 division of a Coast Corps of the Royal Engineers.

"For the ports of Hong Kong, Singapore, Trincomalee, and Port Louis, Mauritius:—

A battalion consisting of 4 companies of Malays and 43 officers and men of the Royal Engineers.

"For the defence of Jamaica for the present we have to depend on a small detachment of Royal Engineers, aided by native labour. However the details for the formation of a native company have been worked out and are under consideration, and there are a number of natives already trained at the port.

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"Submarine mining as an art being practically (in Europe and Asia at least) only about 14 years old, I have always discountenanced laying in large stocks of material in which great improvements are continually being made. I have felt that it would be preferable to get what is required on an emergency at a small cost, which would not really disturb the general estimates of the year, provided no time be lost in issuing the orders when there is any real risk of war. This course ensures our getting the very latest patterns.

"The advance made in our material and methods in the past three years has been very great; our mines are so strong that countermining them will be a matter of very great difficulty.

"Among other points of detail are the following very important ones, viz.:—

"Dormant electro-contact mines have been introduced, by the use of which channels for navigation through the mine systems can be kept open until the last moment.

"The larger mines, which would take the longest to load, are being stored ready loaded, and the priming apparatus ready for insertion.

"An apparatus has been introduced by which observation mines can be fired by one observer, thus obviating the risk of confusion arising from the combined action of two observers.

"The power and efficiency of the electric-light apparatus has been very largely increased.

"The circuit-closing mechanism of the electro-contact mines has been much improved, and is now designed so as to prevent an enemy's counter-mines making the mines self-destructive.

"A number of minor improvements have also been introduced.

"Two new vessels of very superior manœuvring power, which carry a large number of mines on board, have been built. One of these will, it is hoped, shortly be sent to Hong Kong.

"Lastly, I must refer to the great addition to our strength which will be given by the use of the Brennan torpedo. I think I may say the success of this remarkable invention is now assured.

"This torpedo can be propelled and directed from the shore at a rate of 20 to 25 knots for 1,000 yards or more, and meanwhile its course can be varied at the pleasure of the operator on shore. This performance is vastly superior to the Whitehead, which is not under control, and cannot be relied on to strike a ship at a greater range than 300 or 400 yards.

"The steered torpedoes possessed by other countries can only travel about 12 knots per hour.

"All that is really wanted for our military ports now is as follows:—

(1). To construct thoroughly secure test rooms, electric-light engine rooms, and observing and electric-light emplacements at the several stations where they are not already provided.

(2). To complete the *personnel* of the companies of Royal Engineers to the numbers approved in the spring of 1883–84, and to perfect the organization of the Auxiliary Forces.

(3). To strengthen the defences and provide reserve mines after the approved systems are laid down.

(4). To provide guard boats and torpedo boats.

(5). It will be necessary to increase the staff of the Inspector of Submarine Defences by three officers.

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"I cannot however close this memorandum without referring again to the condition of our commercial harbours.

"As I pointed out in my Memorandum of the 20th of August, 1881, looking broadly at the whole question of the defence of the country, our really weak points at the present moment are our commercial harbours.

"It cannot be argued for a moment that, on the one hand, the issue of any great struggle in which this country may be involved would not be materially influenced by the destruction of the accumulated wealth and the trade and the shipping of our commercial harbours; or, on the other, that these ports can each independently arrange for and organize their own defence.

"Even in the case of a minor naval war with Russia (supposing such a war to be confined to the two countries) enormous damage might be done to our ports under present conditions, and the capability of the country to bear the expenses of war be seriously diminished.

"As regards the *personnel*, the measures already approved for the instruction of Engineer Volunteers in submarine mining by a specially skilful body of submarine miners, formed into a Coast Corps of the Royal Engineers, will no doubt, if time were available, be all that is necessary.

"To meet the present emergency however some other measures are required, as there are neither stores nor other appliances for instruction at the several ports, and the time proposed to be spent in instruction under the approved scheme is extended over a long period.

"I would therefore propose to call for volunteers from the company officers and men of the following corps for immediate training at the School of Military Engineering, or other temporary school, for a period of six months under the approved regulations. Their instruction there can be continuous, and carried on by the members of the Coast Corps, with whom they will hereafter be associated.

"The cost of training 4 officers and 96 non-commissioned officers and sappers formed from each corps would, I estimate, be about £6,500 per corps:—

1st Newcastle and Durham Engineer Volunteers.
1st Lancashire Engineer Volunteers.
1st Lanarkshire Engineer Volunteers.
1st Gloucester Engineer Volunteers.
1st Cheshire Engineer Volunteers.
2nd Leeds Engineer Volunteers."

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A table was attached showing the number of mines actually available at the different ports, totalling 1,890 in all. Also a table of the expenditure recommended, which totalled £371,800, with £50,000 for Brennan torpedoes and £20,000 for Nordenfelt's submarine boats.

The actual progress made with the above recommendations will be best seen by resuming the historical summary of events.

1883. In April, 1883, we find the submarine mining companies thus distributed.

The 4th Company was at Bermuda under Capt. Alexander, with a section at Halifax under Lieut. A. E. Wrottesley.

The 23rd Company was at Chatham under Capt. Preston, and had just been formed into the depôt for the Submarine Miners.

The 27th Company was at Chatham under Lieut. Friend, practising at Sheerness.

The 28th Company was at Portsmouth under Capt. de Wolski, with a section detached each year to Pembroke Dock.

The 33rd Company was at Malta undeı Capt. Anstey, with a section at Devonport under Lieut. Rainsford-Hannay, which also practised at Pembroke.

The total strength of the Submarine Mining Service at this period was about 25 officers and 469 N.C.O.'s and men.

In May, 1883, occurred the move to St. Mary's Barracks already referred to, but the year was otherwise uneventful.

Much progress however continued to be made with training and in improvements in patterns of stores, and in the summer of this year the first "rough-water" course took place at Gosport, the company being under Capt. Preston and Lieut. Dumbleton, while Lieut. R. M. Ruck organized and superintended the submarine mining work. This was to give the class of junior officers (the term "young officer" was not then invented) and the recruits an opportunity of practising in deeper and rougher water than could be obtained in the Medway. It was usual at first to take round all mines and stores on a large steam lighter from Chatham, but gradually the Stokes Bay instructional establishment grew to maturity, and a few years later a set of stores for instruction was provided and maintained on the spot. Among improvements in patterns there were many which came from the inventive genius of Lieut. R. M. Ruck, and it is from this period we can date the use of the spherical mine case, the strengthened apparatus with large priming charge, and the retarding circuit closer with silk cord and electrical reversing arrangement, which was based on an earlier design by Bucknill.

About the same date there came in leather washers for all flat joints and a greatly improved method of passing the leads through to the inside of the apparatus, which remedied a very weak point in the gear.

The buildings at Gillingham were also growing under the fostering care of Qr.-Mr. McCulloch, and the mud flats in the neighbourhood were gradually reclaimed and buildings erected. The work was mostly done by convicts from the neighbouring prison. The public pier at Gillingham was at first at the eastern side of the camber, but being damaged by the great storm of January, 1881, the public pontoon was moved to the western side, and the War Department then rented the eastern arm, and about 1883 built themselves a pier.

In October, 1883, Capt. C. C. Carter embarked for India, and was shortly after appointed the Inspector of the Submarine Defences in that country, in succession to Capt. Featherstonhaugh.

In February, 1883, a definite agreement was made with the Brennan Torpedo Company, under which Mr. Brennan received a definite salary for a term of three years, during which he was to give his whole time to the development of the torpedo. These experiments were carried out at Chatham and Sheerness.

1884. The beginning of 1884 was noteworthy for the formation of the first company of Volunteer Submarine Miners at the Tyne.

The corps from which they were taken was the 1st Newcastle and Durham Engineer Volunteers, commanded by Lieut.-Colonel Palmer, M.P. A company 120 strong, under Capts. Allison and Allen, was selected and trained locally in February, 1884, with a detachment of R.E., under Lieuts. Bowles and Quill.

In April, the work at Gosport having increased in volume and importance, Major J. T. Bucknill was appointed Executive Officer Submarine Mining, Southern District.

In May the sections again separated for practice, the 2/27th from Chatham and 3/28th from Gosport going to Cork, and 3/33rd to Harwich, the first submarine mining practice at the latter station.

In July the Submarine Mining Companies at Chatham were formed into a battalion under Major R. H. Vetch, with Capt. C. V. Wingfield-Stratford as Adjutant, and at the same time the instructional work at Gillingham was made independent of the Electrical School.

In the same month Lieut.-Colonel E. D. Malcolm completed five years' service as Lieutenant-Colonel, and leaving the regimental list, had to surrender his appointment at the War Office. Although thus closing his active connection with the Service, he was later Honorary Colonel for many years of the Clyde Volunteer Corps, and always retained the greatest interest in the submarine mining work. Holding, as he did, responsible positions at Chatham and the War Office at a time when much uphill work had to be done to ensure the future of submarine mining, Malcolm's name will always be remembered as that of one of the pioneers of the service.

He was succeeded at the War Office by his old colleague, Major R. Y. Armstrong.

In August, 1884, the Hampshire Militia Corps was re-formed as the "Southern Submarine Mining Militia" with four companies, two for Portsmouth, one for Plymouth, and one for the Thames and Medway.

In September, 1884, a new development of the work was heralded by the trials in the Solent of the *Medina*, the first of the modern type of submarine mining vessel. She was constructed by White, of Cowes, was 100′ long, 17′ 6″ broad, with a tonnage of 140 and a speed of 9 knots. She had single screw with double rudders, so arranged in connection with the under-water lines of the hull that a complete circle could be made with the engine going full steam ahead in 1 min. 12 secs., and on a diameter of only two lengths. She steered nearly as well astern as ahead. The value of such a vessel for laying mines in varying conditions of weather and tide was enormous.

The credit for the unusual design must be given to Colonel Malcolm, who, seeing an account of a similar launch built for the Navy, asked Mr. White to design a larger vessel for the Submarine Mining Service.

These designs were carefully criticized at Chatham, especially to secure the introduction of fittings to enable deck loads of mines to be handled easily and rapidly, when Sergt.-Major Attwood, who had been for nearly 20 years connected with the Submarine Mining Service and was an expert waterman, contributed many useful suggestions.

This vessel, which was afterwards called the *Gordon*, was the first fruit of an arrangement with the Admiralty, by which the responsibility for the supply and maintenance of submarine mining vessels and boats was transferred from the Admiralty to the War Office, a change which much facilitated the introduction of improvements, and resulted in the production of types of vessels which were better adapted to their special work than the older types.

In October the 2/27th from Cork proceeded to Greenock, under Lieut. Tyler, for a training with the local Volunteers, while the 3/28th, under Lieut. Bowles, proceeded to Liverpool for the same purpose. At both stations the experiment was most successful, and excellent reports were furnished on the keenness and adaptability of the Volunteers.

The two sections proceeded to Gosport in November. Meanwhile an important change was being effected in the company organization. In April, 1884, the C Telegraph Troop and the two companies employed with the Post Office had been formed into the Telegraph Battalion, and the company numbers thus released, the 22nd and 34th, were transferred to the Submarine Miners.

At the same time the strength of each company, except the 23rd (Depôt) Company, was reduced from 93 to 62 N.C.O.'s and men, and from three sections to two; the sections thus freed were used to form the new companies.

The 22nd Company was formed in October, 1884, from the 3/33rd Company at Harwich and the 3/4th Company at Bermuda. Its headquarters were at Harwich, under the command of Lieut. F. Rainsford-Hannay.

The 34th Company was formed in November, 1884, at Gosport from the 2/27th and 3/28th. It was commanded by Capt. H. E. Rawson.

1885. In 1885 the threat of war with Russia gave Sir Andrew Clarke the opportunity of putting into practical effect the improvement of the Submarine Mining Service, which he had been elaborating for the previous four years.

The scare was a very acute one, and the mine defences at Singapore and other ports were prepared ready for immediate laying out—the mines were all loaded and primed.

In the Australian ports the mine defences were actually laid out, the only recorded instance of this being done in a British port.

From April 1st the depôt companies at the S.M.E. were identified by letters, and in consequence the 23rd Company became M Company, the old number being transferred to a new field company raised at Aldershot. In the same month the 34th Company, under Capt. H. E. Rawson, with Lieuts. Quill, Grant, and Boyd, proceeded to Malta in relief of the 33rd Company. The Headquarters and the 1st Section of the 33rd Company, under Major Anstey, with Lieut. G. Leverson, moved to Cork, the 2nd Section, under Lieut. Edmonds, going to Hong Kong to prepare the defences there.

In May the first submarine mining officer was sent to the self-governing colonies, Capt. E. F. Rhodes proceeding to Melbourne to take charge of the submarine mining defences of Victoria, with the local rank of Major. Rhodes was succeeded at the War Office as Inspector R.E. Stores by Capt. Rainsford-Hannay, and at the same time Capt. R. M. Ruck was moved from Chatham for special duty in connection with the defence of the commercial ports, on the conclusion of which he joined the staff at the War Office. The staff at Gillingham had been strengthened the previous January by the loan of Lieut. G. A. Carr from the Electrical School, and he now took charge from Capt. Ruck, whose vacancy was filled by Lieut. H. N. Dumbleton, ordered home from active service in Egypt.

On 1st May another company, the 21st, was transferred to the Submarine Mining Service, and was commanded temporarily by Capt. C. V. Wingfield-Stratford, the Adjutant of the Submarine Mining Battalion.

In April the Lords of the Admiralty wrote to the War Office suggesting that anxiety might be felt for the safety of the commercial ports, and suggesting that "the Secretary of State for War may be desirous that naval co-operation should be afforded to the military authorities, who are primarily responsible for their protection." They had therefore appointed Vice-Admiral Vesey Hamilton to consider the nature and amount of such assistance, and asked that some officer of the Royal Engineers might co-operate with him.

Capt. R. M. Ruck was detailed for this service, and with Admiral Hamilton visited the various commercial ports, and discussed the defence arrangements in detail with the local civil and military authorities.

On June 13th a beginning was made with the formation of the Coast Battalion, the first officers appointed being Qr.-Mr. and Hon. Lieut. J. Pring, and Lieuts. Attwood, W. Lawson, J. E. Kilby, and A. Michie, who were stationed at Newcastle, Liverpool, Glasgow, Cardiff, and the War Office.

A beginning was also made with the cadres of the Eastern Battalion, and these various augmentations made it necessary to train a considerable number of men during the summer. To get these a new method was tried, which was attended with the happiest results. Up to now reliance had been placed on volunteers from the batches of recruits to fill the classes both of officers and men; but this was now abandoned, and the necessary numbers were detailed for duty with the submarine miners, whether volunteers were forthcoming or not. So great were the calls for men that for three months the whole of the recruits for the R.E. were transferred to submarine mining.

This big expansion also gave very rapid promotion among the N.C.O.'s, most of whom got two or more steps of rank in the space of a few months! While the day the first batch of young soldiers had finished their submarine mining course 16 of them received their lance stripe, headed by R. Shearburn, who afterwards received a commission in the Coast Battalion. All this naturally threw redoubled work on the Submarine Mining School, as not only had it to cope with four or five times the usual number of men, but the senior warrant and N.C.O.'s were nearly all removed on promotion. Thus a new staff had to be selected, and taught their work, while training was actually in progress.

Fortunately, Lieut. G. A. Carr proved the right man for the emergency; of a singularly exact and orderly turn of mind, and with great natural gifts as a lecturer and instructor, he grappled with all the difficulties as they arose—not the least of which was the want of accommodation both ashore and afloat—and not only carried through the training of the officers and men, but evolved in the process a system of instruction which endured as long as the service lasted.

The instruction of men in those days was in two distinct parts; first, a recruit's course of general submarine mining work, both ashore and afloat, and second, for selected men only, special courses of electricity, engine driving, instrument repairing, or diving.

The recruit's course had been 90 days in length, taking 6 months, but was now reduced to 60 days, or 4½ months. The electrical course took about 6 months, the engine drivers 9 months, instrument repairing 12, and diving 2 or 3, so that in many cases a man was well into his second year of service before he completed his training.

The officer's course included all the work done by the recruits and electricians, with general lectures on the arrangement of a defence and the survey of a minefield.

All ranks were taught signalling with a large flag, and officers and electricians received instruction with the hand lamp and limelight.

Each of the above courses was divided up into subjects, and to each subject was allotted a definite period of 2 to 10 days, and at the end of each period each class was examined practically and *vivâ voce* by an officer. Any failing to reach a definite standard in each subject were put back for further instruction. In this way not only did the officers get a personal knowledge of the men, but the efficiency of the instructors and N.C.O.'s was checked, and a very high standard of work was maintained. At the same time all the ordinary operations were stereotyped and minor details reduced to a rule of thumb, which had to be known accurately. And under this *régime* failures in details such as electrical joints of cables or water-tight joints at mouthpieces of mines were almost entirely eliminated.

In May the School had to receive the first batch of Volunteer officers and about 60 N.C.O.'s and men from various stations. In September Lieut. W. Baker Brown, who had just completed his course, was detailed as a temporary Assistant Instructor, a post which he held for three years.

In July, 1885, the position of O.C. Submarine Mining Battalion, which had been vacant since the previous September, was filled temporarily by Colonel G. W. Stockley, who handed over charge in September, 1885, to Lieut.-Colonel V. G. Clayton.

In September, Capt. C. Penrose, who had been for three years Instructor in Topography at the R.M. Academy, went out to Sydney in charge of the submarine mining defence of N.S. Wales, with the local rank of Major. In November the 2nd Section, 27th Company, went to Bermuda, under Lieut. Hamilton, in relief of the 2nd Section, 22nd Company, which joined the Headquarters of its company at Chatham. The Headquarters and 1st Section of the 22nd Company had done a summer practice at Gravesend, but in November the 28th Company, under Capt. A. E. Wrottesley, moved to that station and became the defence company.

On 1st November, 1885, Colonel E. C. A. Gordon retired under the age rules, and was succeeded as Commandant, S.M.E., by Colonel J. Bevan-Edwards. The newcomer, like his predecessor, was a great supporter of the expansion of the Corps, and in particular took a special interest in the submarine mining work. During his period of rule the Submarine Mining School was frequently visited by senior officials, both civil and military.

During this year there were no important military operations, but the Navy carried out some interesting attack and defence operations at Berehaven, in Bantry Bay, which were attended by Captain de Wolski, R.E. The operations, which were the most extensive which had been arranged by the Navy up to that date, were carried out by the Channel Squadron, under Admiral Sir G. T. Phipps Hornby, K.C.B.

Both ends of the haven were defended by a minefield of ships and boat mines, and at the eastern end there was a boom made of ships' spars, moored so as to form a continuous barrier across the channel.

Various attacks were made on these defences, in one of which H.M.S. *Polyphemus* charged the boom and cut through it with the greatest ease and without the slightest shock, a result which should have been expected after the experience at Portsmouth in 1879 and 1880, but appears to have been a surprise to many officers present.

Considering the improvised nature of the mine defence, the mining operations were very good, but the absence of fixed firing stations and a careful survey made the defence much less effective than was obtained at this time by the R.E. in every summer practice.

The transfer of so many companies to the submarine mining and other special branches of the Corps of Royal Engineers had caused a great scarcity of officers and men for the ordinary field and fortress duties. This was strongly represented by Sir J. Stokes (D.A.G.) and Sir A. Clarke (I.G.F.), and as the result a special Committee was assembled on 31st July, 1885, to report on (*a*) the necessary duties devolving on the Corps of Royal Engineers; (*b*), the strength of officers and men, and the number of cadres that should be maintained during peace. The first President was the Earl of Morley, Under-Secretary of State for War, but before the proceedings terminated he was replaced first by the Hon. Guy C. Dawnay, and then by *Lord Sandhurst. The members included General Viscount Wolseley (Adjutant-General), *Lieut.-General Sir A. Alison, Bart., Major-General Sir C. G. Arbuthnot, *Major-General H. A. Smyth, *Major-General Sir A. Clarke (I.G.F.), *Major-General Sir R. H. Buller (D.A.G.), *Major-General Sir J. Stokes (D.A.G., R.E.), *Mr. R. H. Knox (Accountant-General). *Capt. L. Darwin, R.E., was Secretary. Those marked with an asterisk signed the final report.

Two proposals for alterations in duties were made to the Committee, one by Major-General Arbuthnot, that submarine mining should be transferred to the Artillery, the other by Sir R. H. Buller, that the Telegraph Service should be made a separate corps. Both caused considerable discussion, and both were negatived.

The strength of the Corps was discussed on memoranda and tables proposed by Sir A. Clarke and Sir J. Stokes, and resulted in a recommendation to add to the Corps 23 companies, with a strength of 126 officers, 1,748 warrant officers, N.C.O.'s, and men, and 361 horses.

The increase to the Submarine Mining units was only one Regular Company, but there were considerable increases to the Coast and Eastern Battalions, and the total recommended for the

Submarine Mining Service was one lieutenant-colonel, 75 other ranks of combatant officers, with five quartermasters and 972 warrant and N.C.O.'s and men. The staff at Headquarters and at the School were in addition to these figures.

Besides this the number of submarine mining storekeepers was raised from 13 to 20, the number of mechanists for charge of engines from 6 to 28, while two new classes of electricians and masters for steam vessels were recommended with establishments of 48 and 24 respectively.

This was the beginning of the valuable class of military mechanists who under the officers are responsible for the technical efficiency both of *matériel* and *personnel*.

One marked feature of these recommendations was a proposal to group the various Companies of the R.E. into Battalions, with a quasi-battalion organization. This was partially applied for several years, but failed, as will be seen later.

1886. The year 1886 opened with the appointment of Capt. R. M. Ruck as Assistant Inspector, Submarine Mining Defences, with local rank of Major, and on 30th January Lieut. G. A. Carr was formally transferred from the Electrical to the Submarine Mining School, and was succeeded in the former by Capt. R. L. Hippisley.

On 16th May, Capt. A. T. Preston was appointed Instructor in Submarine Mining, and the School Staff at Gillingham was thus fully constituted, with Capt. Preston as Instructor, Lieuts. Carr and Dumbleton as Assistant Instructors, Lieut. Baker Brown as Temporary Assistant, Lieut. McCulloch as Quartermaster, and Mr. J. Parry (late R.N.) as Instructor in Engine Driving and Superintendent of Submarine Mining Machinery. The latter officer had been transferred to the Submarine Mining Service the previous year, when the charge of the submarine mining boats was taken over by the War Office. Mr. Parry remained at Gillingham for 15 years, and did yeoman service in putting the instruction of engine drivers on a sound basis.

In May, 1886, the 35th Company was formed at Chatham under Capt. G. A. Tower.

In June the 22nd Company, under Capt. O. E. Ruck, and the 30th Company, under Lieut. Van Straubenzee, were sent to Pembroke Dock and placed under the command of Capt. Rainsford-Hannay, who had been lent from the War Office in connection with special combined naval and military operations at Milford Haven.

These experiments, which originated in the office of the Inspector of Submarine Defences, were very important, indeed, as it turned out the most important submarine mining experiments with opposing forces carried out in the British Service.

In the words of the Chief Umpires: "For the first time in the history of similar operations a first-class port, the seat of one of the building establishments for the Navy, placed in a state of defence in accordance with the latest ideas, was to be attacked by a naval squadron fully equipped and in every respect prepared for active warfare."

Milford Haven, which was selected for these experiments, is an inlet of the sea running east and west for several miles inland, with a width of about 2,000 yards.

The position selected for the experiment is divided into two unequal parts by a rocky islet called Stack Rock, on which was a strong casemated fort.

A portion of the main channel south of Stack Rock, 700 yards wide and 3,000 yards long, was buoyed off as the area for the operations.

This area was defended by—

12 counterpoise E.C. boat mines in pairs 60′ apart, connected together by wire rope. These were placed in front of all other defences.

16 E.C. mines and 6 single 500-lb. observation mines.

A wire entanglement made of old circuit-closer jackets and wire rope.

A boom of ladder type made of 30′ baulks of timber, 12″ × 12″, about 12′ apart, and connected by four lines of chains on top and strongly moored. This boom was constructed by the local Engineer contractor, but was not quite completed for want of time.

The boom was abreast of Stack Fort, but a channel 150 yards wide was left between the boom and the fort as a friendly channel. It was defended by two lines of three mines each fired on the line system. Behind the boom there were first six more single observation mines and then ten groups of E.C., forming four rows across the channel.

The cables in the outer minefield were protected by old chain and cable laid in front and behind, and all junction-box buoys were removed before the attack began.

In the inner minefield the cables were not so well protected and the buoys were left in place.

The gun defence consisted of 16 10″ R.M.L. and 7 9″ R.M.L. in Stack Fort, and 6 9″ R.M.L. and 15 7″ R.M.L. in South Hook Fort, to the north of the channel. There was also a battery of 6 9-pr. field guns on the south shore, representing 40-prs.

The Electric Light defence consisted of three stations, one on Stack Rock running a single light of old type, and two at South Hook, each capable of providing power for one 3′ and one 2′ projector. The lights at South Hook were distant 3,000 yards from the extreme end of the minefield and 600 yards from the nearest point.

In fact, to modern ideas, only the inner portion of the minefield could have been at all effectively lit.

The defence was further assisted by a flotilla consisting of H.M.S. *Valorous* and three gunboats, which were anchored at the inner limit of the minefield, and by four second-class torpedo boats, ranking as first-class for the purpose of these operations, and six pinnaces acting as guard boats.

The Attacking Force consisted of the Channel Squadron, under the command of Vice-Admiral Sir W. Hewett, V.C. It consisted of five battleships—H.M.S. *Minotaur, Iron Duke, Sultan, Monarch*, and *Agincourt*, the torpedo depôt ship *Hecla*, four gunboats, five first-class torpedo boats, seven second-class and four countermining launches.

The Chief Umpires were Lieut.-General H. A. Smyth and Capt. G. S. Bosanquet, R.N. A War Office Committee, under the Presidency of Colonel Schaw, R.E., watched the proceedings.

The operations commenced on the 17th August by the arrival of the Attacking Squadron, who at once anchored close to the outer edge of the mined area and within easy range of the defending guns, and proceeded to get out torpedo boats and launches without protecting themselves with nets. The Umpires at once ruled the *Hecla*, which was unarmoured, out of action unless she was moved further away. The Admiral replied that he did not intend to move the *Hecla*, and shortly after hoisted the signal to suspend operations. The fleet thereupon took no notice of attacks by Defence guns and torpedo boats, but continued their preparation of countermines and launches.

The Admiral later explained that the conditions of weather did not permit of his anchoring further away, and further claimed that it must be assumed that there had been an artillery combat, in which the whole of the artillery, infantry, and machine guns of the Defence had been put out of action.

To enable the experiments to continue the Umpires accepted the Admiral's view, or at least allowed him to have his way, and the operations were resumed on the evening of the 17th.

During the day some countermining launches and gear, which had been prepared in Pembroke Dockyard itself, were sent out through the Defence for the use of the attacking fleet.

The operations began at 7.50 p.m. by the Defence guard boats taking up positions to cover the advanced minefield; it was still daylight, and they were fired on by the fleet, which was only 1,500 yards distant, and put out of action, but did not retire.

Both Defence and Attack then started their electric lights, and at 8.50 four Defence torpedo boats started to attack the fleet. Each boat fired two or three torpedoes, but all the ships were protected by nets except the *Hecla*, which was put out of action. One torpedo boat was also ruled out. The Attack torpedo boats thereupon advanced under cover of smoke and attacked the guard boats, which retired, firing a rocket as a signal. The torpedo boats reconnoitred as far as the entanglement, were seen in the electric light, and turned back.

At 10 o'clock the three Defence torpedo boats made another attack on the fleet, passing through a number of boats creeping in the outer minefield. The ships were still protected by nets. One of the Defence boats was fired on by her own side when returning.

At 10.30 a charge was attached to the boom by a boat which should have been out of action. The explosion made a large breach in the boom.

Meanwhile the firing battery had been put on the advanced boat mines, but not on the remainder, though several of the outer mines signalled through contact with vessels passing through the minefield.

At 10.35 two of the pairs of boat mines were struck by two hostile boats and were fired. One of these boats contained the Vice-Admiral himself; the other was not identified.

At 10.48 the first lines of countermines were laid by boats from the *Iron Duke*, but unfortunately were laid outside the limit of the operation area, and were ruled out. This was bad luck for the Attack, as such an event would not have happened in real warfare. A second series was successfully run by the *Minotaur*.

At 11.11 the *Hecla's* pinnace laid a second charge on the boom. The boat which affixed the charge was ruled out of action after firing, but the Umpires allowed that the charge could have been exploded.

At the same time the remaining two Defence torpedo boats made their third attack; one was put out of action, and one struck a mine of the defence and was blown up.

At 12.4 the third charge was put on the boom and fired, but again the boats doing it were ruled out of action.

At 12.30 the gunboat *Seahorse* charged the boom, but was ruled out of action by gunfire and also by an observation mine.

At midnight, the minefield being full of attacking boats, the firing battery was put on the advanced electro-contact mines and remained on for an hour, during which four mines were fired, destroying one line of the *Agincourt's* countermines and another boat.

At 1 a.m. the fourth charge was successfully laid and fired at the boom.

The operations were suspended at 1.10 a.m.

It is difficult from the above bald narrative to get a real glimpse of the extraordinary nature of these operations. Once the attack was developed the whole area was full of boats, creeping, laying countermines, or attacking the boom. The actual effect of fire was poorly represented by the umpires' decisions, and some boats were out of action two or three times. In fact, everyone was keen to have a hand in the game, and every available boat in the fleet was afloat with some form of creeping tackle. Many of these had no umpires, and their efforts were not recorded.

It is reported that one boat was found which was owned and manned by a retired naval officer, who, overcome by the smell of powder, could not refrain from a little creeping on his own account.

The minefield was for most of the time more or less shrouded in a cloud of smoke, drifted in by a light wind, which favoured the attack in this respect, and this cloud was only dimly and uncertainly pierced by the rays of the electric lights of the defence.

Add to this the flashes from the guns, the whirr of signal rockets, and, over all, the serene calm of a full moon in a cloudless sky, and the medley of sights and sounds may become a little more real.

It is small wonder that even those officers who were in a position to know more or less what was happening were uncertain as to the true bearing of the operations, while the newspaper correspondents who had flocked in from all corners of the kingdom were absolutely bewildered, and as the only visible effect was the damage to the boom and some mines, recorded the day's result as a victory for the attack.

A summary of the casualties reveals the following position. The Attackers were adjudged to have lost—the *Hecla*, two gunboats, three torpedo boats, one countermine launch, and 21 smaller boats, one containing the Admiral.

The Defence had lost all their guard boats and torpedo boats, had fired six mines, and had seven destroyed by countermines. The boom had been twice breached effectively and a narrow channel had been cleared by countermines up to the entanglement.

The following afternoon the operations were resumed by the advance of the *Iron Duke* up the countermined channel to about 700 yards from Stack Fort. This advance was made in daylight, and the Attack then proceeded to lay out and fire countermines all round, so as to give the vessel room to swing.

Such an advance would not have been possible unless the artillery of the Defence had been silenced; but though they did not fire on the *Iron Duke* at the time, the guns took part in the night operations the same night, which were resumed about 8 p.m. under rather less favourable atmospheric conditions.

The *Iron Duke* was used as a base from which countermine and creeping boats were despatched on their errands of destruction, while the attacking gunboats advanced through the boom and tried to cut mines adrift. In short, the medley of the previous evening was resumed with increased spirit. One launch of the attack, ruled out of action, covered up her identification number, and, returning to the *Iron Duke*, towed out and laid two successive series of countermines, being ruled out of action on each occasion. Another, after being theoretically sunk, proceeded to cut mine cables which had not been protected in the inner minefield, and made three groups of E.C. mines useless.

The mines were eventually credited with having sunk four more of the attackers on this evening, while 12 boats were supposed to have been sunk by artillery fire, and the *Iron Duke*, which was not protected by nets, was torpedoed. On the other hand, the minefield was extensively damaged.

But on the whole the result of the operations was that the Defence, though sorely battered, had succeeded in holding on to their defences, and were to this extent successful. While the attack, though it had exhausted its whole supply of countermining stores, including some prepared in the port it was attacking, and had lost numerous men and boats, had not succeeded in clearing a practicable channel through the minefield.

Of minor results from these manœuvres the following may be noted:—

On the side of the Attack it was shown that the Navy had developed their system of countermining on a practicable scale, and were capable of carrying out the operations with skill and great celerity. Their attacks on the boom were clever and successful. They had also developed a suitable method of using electric lights in the attack to screen their own side and dazzle the enemy.

Their principal defect was a fixed determination to win at all costs, which, however valuable in real warfare, detracted very considerably from the usefulness of the operations.

On the side of the Defence, the palm must be given to the mining work, which, under the conditions, was good and effective. The boom was less satisfactory, though it may be claimed it did its work in compelling the attack to expend men and time in its destruction. It had been breached in two places by civil traffic a day or two before the operations. The artillery also appears to have been well served, though it was credited with rather large powers of execution.

Probably the weakest part of the Defence was the electric lights, which had only been installed for these experiments, and were quite inadequate in range or number for the work required. There was also no proper scheme for working them in concert with the guns and no previous practice in combination with the artillery.

The Chief Umpires, in their report, after referring to some of the unrealities mentioned above, criticize the attack of the Defence torpedo boats on the fleet as foolhardy, but point out that the fleet, having anchored so close to the minefield, deprived the Defence torpedo boats of much of their value.

They also criticized the action of the guard boats in getting too near the attack and the action of the artillery in firing on their own guard boats.

As regards mines, the Umpires were of opinion that the Defence had rather benefited by the artificial boundary of the minefield, and they criticize the boom as being insufficiently strong, badly moored, and not provided with spikes * and other projections to damage attacking boats. Both mines and boom were damaged by passing traffic before operations began, and the Umpires comment on the necessity of a proper system of pilotage at all defended ports.

The working of the defence electric lights was severely criticized, that of the attack praised.

References were made to the absence of means of communication between parts of the defence and the necessity of avoiding firing on defence boats retiring across the defended area.

But the main lesson of these manœuvres—a lesson which was not fully acted on for many years afterwards—is summed up in the following extract from the report of the War Office Committee :—

> "It is now established as an undeniable fact that the defence of a harbour by the combined action of artillery, mines, electric lights, and flotilla is not an operation which can be effectively carried out without previous practice under a selected officer, who has at least some knowledge of the way in which these various means of defence can be used, and who has drilled the different arms together and established a good system of combined action."

Both Umpires and the War Office were agreed that before further operations were carried out on a large scale it would be necessary to have minor operations at some of our smaller ports.

Only one such operation actually took place in 1887, and it may be best to interrupt the regular course of the narrative and give a short description of it here, immediately after that of Milford Haven.

The place selected was Langston Harbour, a few miles east of Portsmouth. This was chosen as having a narrow channel much used for shipping, while its proximity to the Naval Dockyard would make it unnecessary to use any of the larger ships to organize the attack. The width of the entrance is about 400 yards and the depth of the defended area was about 2,500 yards. The defence consisted of an outer minefield represented by one group of E.C. mines, supplemented by dummies and naval electro-mechanical mines. Then four groups of 50-lb. E.C. boat-mines, placed across the channel in front of an obstruction of wire rope and buoys. Then a main minefield represented by five groups of E.C.'s.

* These projections are necessarily absent during peace operations.

Special moorings were laid for guard boats just in rear of the obstruction and also among the advanced mines. The guard boats were provided and maintained by the Navy, who also undertook the control of the traffic during the preparation of the defence. The minefield was well laid out by the 4th Company, R.E., under Lieut. Sealy Vidal. The minefield and obstruction were defended by a battery of quick-firing guns on each shore, each battery being represented by two 6-pr. Q.F. guns borrowed from the Navy. There were also supposed to be machine guns, which were represented by infantry.

Four electric lights were provided, two on each shore; one of these was allotted to the Q.F. battery, and had alternative emplacements on either flank of the battery. These lights worked on the "fixed-limit" principle of traversing through a small arc of 20° to 30°.

The other two lights were placed further out to each flank, and directed so as to cross about the front of the advanced minefield.

The Defence was commanded by Colonel J. H. Maitland, R.E. The Attack was under the orders of Capt. Samuel Long, R.N., and consisted of 8 gunboats, 2 large torpedo boats (4 of these 10 carried electric lights), 5 other torpedo boats, 9 other steamboats, 35 pulling boats, 6 smoke boats, and 8 smoke rafts.

It was divided into various sections for countermining, creeping, etc.

The operations took place on the evening of 18th October and proved somewhat disappointing. The tide was very strong in and out of the harbour, while off the mouth there was a bar which could only be crossed by the attacking boats at half tide. It was therefore found necessary for the Attack to cross the bar carefully and anchor among the advanced mines before commencing operations. Also in order to shorten the time required, and as it was thought to simplify the experiments, the Attack were given detailed plans of the defensive arrangements, which they supplemented by personal visits (in plain clothes) to the scene of operations during the preceding week.

It was expected that the operations would be extended over three nights, but the effect of the above factors was such that beginning promptly at 9 p.m., by 10.32 p.m. the Attack had countermined the whole length of the defence, though not very accurately, and had also cut cables and obstructions in sufficient number to make the Defence almost useless. On the other hand, the Attack lost a quarter of their steamboats and numerous smaller craft.

An interesting feature of the Defence was an attempt made by Lieut. Sealy Vidal to lay extra mines across the countermined channel. A line of contact mines on the ⊥ system was successfully laid, but the cable was caught and cut by an attacking boat. He also laid some electro-mechanical mines without being detected.

The operations having come to a premature conclusion, an evening was devoted to trials with various forms of electric light, in which dispersing lenses were used for the first time in the military service.

The lessons derived from these experiments were summed up by the War Office Committee as under :—

Guard boats should normally be at fixed moorings placed in rear of the main obstruction. In thick weather one or two boats to lie at fixed moorings in the advanced minefield. Boats not to move without the permission of the O.C. Defence.

Electric lights should be arranged on the " fixed-limit " system.

The obstruction was very effective against craft which entered the harbour previous to the operations, but was much damaged by them, and was, on the night of the 18th October, carried under by the strong and high tide.

The boat mines proved effective, 4 out of 16 being adjudged to have blown up attackers.

The means of *protection of the cables* proved effective.

The effects of *smoke* were much less than on previous occasions, due to the direction of the wind favouring the Defence.

One point was very strongly commented on by the Umpires and Committee, and that was the defective arrangements made for controlling the traffic. These arrangements proved quite inadequate, probably on account of a misapprehension of the work to be done and a want of local knowledge of the conditions of tide and soundings.

One evening when the obstruction was nearing completion a naval gunboat steamed into the harbour right over it, dragging all the buoys into a heap, and then anchored in the middle of a group of mines, damaging two mines. There were several similar incidents.

It was from such failures that there arose an idea that the pilotage of friendly vessels through a minefield was an essentially difficult and risky operation !

It happened that these were the last operations of this kind in which mines were actually laid out as part of the Defence, and the occasion is thus opportune to refer to two points which do not occur in subsequent combined operations. These are countermining and the duties of guard boats. The former had by this time been developed to a very high degree of efficiency by the Navy, but it suffered from two disabilities which then and now affect its usefulness. These were the large amount of material required and the great accuracy required when laying. The amount of material even for a small harbour like Langston was equal to that carried by a powerful fleet, while in a large defence suitably arranged it might be necessary to countermine a distance of 2 or 3 miles of channel. As this is the only method of clearing a mine defence under fire, it follows that a carefully-arranged minefield may be regarded as probably effective until the whole of the artillery of the Defence has been silenced or captured, or in other words the mine had been proved capable of doing its work of compelling the attackers to engage the Defence guns.

The *rôle* of guard boats had been gradually accepted as that of floating platforms for gunfire over the minefield, while they could not manœuvre, as if they did they were liable to destruction by their friends. The necessity for guard boats arose very largely from the use of smoke tactics by the Attack and the firing of the heavy guns of the Defence, and thus as smokeless powder was introduced and the electric light defence was developed, and also the range of guns, the *rôle* of guard boats gradually disappeared, though the final decision on this point was not reached till 1892.

The question of the provision of guard boats had been the subject of much discussion between the War Office and Admiralty ever since the operations in 1878—1880.

Although essentially a service for which the naval training was specially suitable, the Admiralty at that time adhered to their decision not to tie any boats to particular ports. The duty thus devolved on the Army, and arrangements were made in estimates in 1886 for the provision of boats, while additions were made to the establishments of the Submarine Mining Militia to provide the *personnel*, but for various reasons special boats were not actually provided, so that this service would have had to be done with hired tugs and steamers.

It is however worthy of note that the arrangements included, in addition to the actual guard boats to watch the minefield, patrol boats and examining vessels to deal with traffic, which were to be entirely under military control.

At the conclusion of the operations at Milford Haven in November, **1886.**
1886, the two Companies which had carried out the work were moved to other stations, the 22nd Company proceeding to Gosport, and the 30th Company to Plymouth. In the same month the 4th Company from Bermuda was brought home to Chatham under Capt. H. de H. Haig, being relieved by the 27th Company from Devonport under Capt. H. E. Rawson, while the 28th Company moved from Chatham to Gravesend under Capt. Wrottesley to prepare the defences at that station. Among other things Capt. Wrottesley on this occasion carried out a very careful and elaborate survey of the minefield, which was made the basis of the official instructions on this subject.

The same month the first start was made with the formation of the Eastern Battalion, Capt. M. D. Whitmore, who had been appointed Commandant with local rank of Major, arriving at Singapore on 11th November, 1886. The detachments of M Company stationed at Singapore, Hong Kong, Trincomalee, and Mauritius were made the nucleus of the Companies of the Battalion under the command of (local) Capt. W. G. Shellabear, Lieut. J. E. Edmonds, (local) Capt. F. V. Jeffreys and (local) Capt. W. M. Hodder. Shellabear acted as

Adjutant of the Battalion, and the Staff at Singapore was completed by Qr.-Mr. and Hon. Lieut. J. Bull and Serjt.-Major J. Organ.

It was intended to supplement these European detachments, which were about 10 to 20 strong, by larger bodies of natives, and an attempt was made to enlist Malays, who had proved most useful during the combined trainings at Singapore. But at first the Malays could not be induced to take the shilling, and when at last a sufficient number had been obtained for the local defences, they steadily refused to be drafted to other stations. Major Whitmore thereupon visited Ceylon and Mauritius, and succeeded in starting the formation of locally enlisted units. Hong Kong however proved more difficult, as though the local Chinee was a first-class boatman and a good fellow, it was doubted whether it was politic to enlist and train him as a soldier.

1887. In January, 1887, a final decision was reached to purchase the exclusive rights in the Brennan torpedo for a sum of £110,000, to be paid in instalments, and Messrs. Brennan and Temperley were retained in Government employment to superintend the manufacture of the torpedoes.

In February, 1887, deafness unfortunately occasioned the retirement of Major Bucknill, and he was succeeded as Executive Officer at Gosport by Major Anstey. Major Bucknill had nearly completed 20 years in the Submarine Mining Service and had seen its growth from the earliest days. For nearly the whole of his service he had held important positions, and from the days of the Torpedo Committee onwards had contributed as much as any officer to the successful evolution of the material. After retirement he contributed materially to the literature on the subject, and took up the pen in defence of his favourite arm in various paper controversies against Sir G. S. Clarke and others.

In January the 35th Company moved to Sheerness under Capt. M. J. Slater, moving on to Pembroke Dock in September.

In April the 4th Company moved to Harwich under Capt. Haig, moving on to Gosport in July under Lieut. W. Sealy Vidal for the Langston operations.

In July Capt. H. P. Knight, who had completed seven years as Adjutant to the Southern Submarine Mining Militia, gave place to Capt. H. de H. Haig, and a few months later left for the East to be stationed at Hong Kong as Assistant Commandant of the Eastern Battalion.

Knight had succeeded in making himself very popular with all ranks of his Militia Corps, whose numbers and efficiency developed very considerably during his period of office. It was largely due to him that the Submarine Mining Militia was started on a practical basis.

On 1st October, 1887, the Submarine Mining Service bade adieu to another good friend in the person of Colonel V. G. Clayton, who was in command of the Submarine Mining Battalion. Although not a trained submarine miner, his previous experience with the R.E. Committee enabled him to grasp the essential points of the system, and whether in the orderly room, in committee, or showing senior officials round the school and barracks, of which a good number fell to his lot, he was always ready to support the best interests of the growing service. The Officers' Mess at St. Mary's and the various regimental institutions also owed much to his advice and assistance.

The 28th Company from Gravesend rejoined at Chatham in August, and for the next five years remained nominally part of the Submarine Mining Battalion, though proceeding for the greater part of each year to Gravesend for practice. There were no other moves of Companies during the year. The changes in patterns of stores during these two or three years were not very marked and were principally in the direction of simplifying both patterns and drill.

Some very important experiments were carried out by Capt. H. E. Tyler at Devonport and elsewhere, including a valuable series of countermining experiments at Cardiff in 1887.

Perhaps the most noteworthy change at this time, in addition to the gradual growth of the Brennan torpedo, was the development of the Watkin Position Finder and its adaptation for firing observation mines.

In January, 1888, Lieut. G. A. Carr was called to the War Office **1888.**
to re-write the Manual of Submarine Mining, and was succeeded at the Submarine Mining School by Lieut. F. R. Reynolds. In April Brevet Colonel K. R. Todd became O.C. Submarine Mining Battalion.

In May several moves of Companies took place; the 21st Company from Chatham proceeded to Harwich under Capt. Von Donop, and the 33rd Company from Gosport to Cork Harbour under Capt. H. A. L. Patterson. The same month the 39th Company was formed at Chatham under Lieut. E. Druitt. On the 1st June the Portsmouth Militia Corps was split up into Divisions which replaced the localized Companies, and new Divisions were formed for Milford Haven, the Severn, and Harwich.

The same year a beginning was made in the appointment of Quartermasters in charge of submarine mining stores, Lieut. G. H. Hitching being posted to Gosport and Lieut. G. G. Gibson to Jamaica.

The organization of the submarine mining at Gosport was at this time on a Battalion basis, with Major Anstey as O.C. and the Adjutant of the Militia as Adjutant of the Battalion. The two or three Companies at the station were distributed between Forts Blockhouse and Monckton.

In August Capt. C. C. Carter died suddenly in India, and was succeeded a few months later as I.S.D. by Capt. P. Von Donop.

In October the 40th Company was formed at Halifax out of the 27th Company, and was commanded by Capt. H. E. Rawson.

This completed the total scheme of R.E. Companies for the Submarine Mining Service. It will be noticed that by this time they were fairly localized, but they still retained the fixed establishment of 62 N.C.O.'s and men.

The Coast Battalion had meanwhile been augmented by about two officers a year, and Submarine Mining Volunteer Corps had been formed at Newcastle, Liverpool, Glasgow, Cardiff, Dundee, Hull, Edinburgh, Middlesborough, and Falmouth. This had not however been effected without a certain amount of trouble. At first the Volunteer Companies were all formed as Companies of existing Corps, but this arrangement did not last, as the submarine miners had a longer period of training and earned a higher capitation grant, so that eventually it was found necessary to give them their own separate organization and form them into separate corps.

In November the detachment of M Company at Jamaica was formed into a local Company under Lieut. W. P. Brett and started enlisting natives.

In the same month Lieut. Baker Brown was ordered to Mauritius and was replaced as temporary Assistant Instructor by Lieut. H. B. Roberts.

1889. Early in 1889 there were several changes in the Australian Colonies, Capt. Rainsford-Hannay going out to Victoria, vice Rhodes, and Capt. de Wolski to Sydney, vice Penrose, while Lieut. Druitt went to Queensland. In all cases these officers acted as advisers to the local government on defence matters and as C.R.E. of the local forces.

Rainsford-Hannay was succeeded at the War Office and as I.R.E. Stores by Capt. H. E. Tyler from Devonport, while Penrose went to the War Office, vice Carr, who was ordered to Bermuda to command the 27th Company.

In May Capt. M. J. Slater succeeded Haig as Adjutant to the submarine miners at Gosport, and in July Capt. S. R. Rice, recently arrived home from India, was appointed Adjutant of the Chatham Battalion, vice Wingfield-Stratford. Moves of Companies during this year were limited to those of the 28th Company, Chatham to Gravesend, and the 22nd Company, Gosport to Isle of Wight for summer practice, the 22nd Company assisting in a valuable series of electric-light experiments, which is dealt with later.

In December, 1889, Capt. H. E. Rawson was appointed Secretary R.E. Committee, vice Friend.

The failure to enlist Malays for service outside Singapore made it necessary to modify the organization of the Eastern Battalion, and in February, 1890, the battalion organization was given up and the local company at each port became an independent unit of the Corps of Royal Engineers, and the C.R.E. was made responsible for recruiting, clothing, and local regulation of the enlisted natives. **1890.**

Major Whitmore was brought home and replaced by a Lieutenant-Colonel, who became C.R.E., Singapore, but Major Knight was continued for a year longer in charge of the mining defence at Hong Kong.

In May, 1890, Capt. W. S. Vidal gave up the command of the 30th Company at Plymouth, and was appointed experimental officer for the Submarine Mining Service. This was a new appointment, rendered necessary by the increasing amount of experimental work which was being undertaken. In November the experimental officer was moved to Gosport, where he took charge of the Stokes Bay instructional establishment and helped with the rough-water classes.

In April Major Whitmore, on return from abroad, took command of the Submarine Miners at Gosport, vice Anstey, and in August Capt. J. E. O'H. Hamilton was appointed Adjutant, vice Slater.

The same month Lieut. Seaman was appointed an additional Assistant Instructor at the Submarine Mining School, Chatham, for Brennan torpedo work.

In May Lieut. W. G. Lawrie succeeded Dumbleton as Assistant Instructor at Chatham, and the latter, after some months in charge of a rough-water practice at Gosport, left for Hong Kong in relief of Major Knight.

In August Lieut.-Colonel H. P. Lee was appointed O.C. Submarine Mining Battalion. In December Qr.-Mr. McCulloch was given the honorary rank of Major, and became Quartermaster to the School of Military Engineering. A well-known figure at Gillingham for the last 10 years, he had been indefatigable in developing the material side of the School. Except once, in 1885, when the supply of india-rubber tape and solution ran short owing to the abnormal demands for instruction, McCulloch prided himself that he was never at a loss for stores, and he always managed the business side of the work at Gillingham with conspicuous zeal and ability.

In this year an attack was made by Major G. S. Clarke, R.E., on the whole system of mine defence in the pages of the *Proceedings of the R.A. Institution.* The details are discussed later.

The same year accidents took place at New South Wales and Mauritius, in each case resulting in the death of several men. Neither of these were however with actual service mines, and from first to last of the 40 years of the Submarine Mining Service there was no recorded case of a fatal accident caused by the explosion of a service mine.

In order to save expense, it was customary to practise the actual firing of a charge of explosive by means of what were termed extemporized charges, and several of these were fired yearly at each station. They differed from the service mines in the fact that the charge was enclosed in an india-rubber bag instead of the steel mine case, there was no testing apparatus in the charge, and the arrangements for mooring were extemporized. There was thus much more risk of damage to the charge or its cable.

In the case of New South Wales, a party of the local forces was laying and firing two such charges from a cutter, on an occasion of a public holiday, when by some mistake, after one charge had been laid, the firing apparatus, which was in the boat, was applied to the cable of the charge which remained in the boat, blowing the latter to pieces and killing or drowning two officers and two men.

In the case of Mauritius, the accident occurred at night, with a strong sea. A launch, which was representing an attack on the harbour, laid and fired a charge to represent countermining. The charge was not however laid clear of the vessel, and when fired the stern was blown out, the vessel sunk, and two of the ten men on board were drowned.

In addition to these two accidents, there was one case in the early days of submarine mining in India, when an extemporized charge, which was being soldered up in a tin case, exploded, and one case later on when a man was burnt to death by the spontaneous combustion of a charge of guncotton which he was unloading, and which he had allowed to get too dry. The number of minor accidents was even smaller, and on the whole it may be fairly claimed that the Submarine Mining Service was conducted from first to last with a smaller number of casualties to life and limb and with greater care of the gear than almost any branch of the Army and Navy.

1891. In April, 1891, Capt. Reynolds went to Victoria as an additional R.E. officer, and was succeeded as Assistant Instructor by Lieut. H. B. Roberts, who had been temporarily employed at the Submarine Mining School since the end of 1888.

In July there occurred considerable change among the *personnel* of the War Office, on Colonel R. Y. Armstrong vacating his appointment as I.S.D. on completion of five years as Lieut.-Colonel.* He

* Of Colonel Armstrong's work for electrical science both inside and outside the War Office a volume might be written. It is only possible here to mention some facts of his career to supplement the account of his work for the submarine mining and other military electrical services which is given in this book.

was succeeded by Major R. M. Ruck, who was himself replaced by Capt. C. Penrose, while Capt. A. H. Randolph was brought in from Gosport to complete the War Office Staff.

Meanwhile the battalion organization at Gosport had been found unsatisfactory, and in August it was broken up, Major Whitmore and Capt. Hamilton joining the staff of the C.R.E., Southern District. At the same time the 22nd Company was definitely allotted to the Needles defences and quartered in Fort Victoria at the west end of the Isle of Wight, while the 4th Company remained at Gosport as the defence company for Spithead. Capt. Vidal became D.O.S.M., Spithead, as well as Experimental Officer, and Capt. Lawrie was moved from Chatham to command the 4th Company and to take charge of the Stokes Bay instructional establishment, which was used as an overflow from the Chatham School.

At Chatham the 39th Company had been moved to Sheerness in November, 1890, and had remained there to carry out a Militia

R. Y. Armstrong was born in 1839 of Irish descent, and was educated at Trinity College, Dublin.

Commissioned in 1858, after the usual courses at the S.M.E. he served at Dover from 1860 to 1863, during which period he supervised the construction of Fort Burgoyne. From 1863 to 1868 he was in Canada, whence he visited the battlefields of the United States in 1864. From 1868 to 1870 he served as an unpaid Assistant Instructor in Signalling at the S.M.E. under Stotherd, and during this time no doubt laid the foundation of the electrical studies which were to bear such fruit. In June, 1870, he was temporarily stationed at Aldershot to instruct the troops in signalling, but in 1871 he was recalled to Chatham as the first Assistant Instructor in Submarine Mining. He remained at Chatham as Assistant Instructor and Instructor till 1883, when he was lent to the Board of Trade as adviser in drafting provisional orders under the first Electric Lighting Act.

There was then no experience available; but Armstrong tackled the job with his customary thoroughness and originality and laid a sound basis for what is still the best-regulated branch of similar Government services.

In 1884, on the expansion of the Submarine Mining Service, Armstrong was called to the War Office, but continued to advise the Board of Trade till 1888, when he found the double work too much for his energies.

In 1891 he left the War Office and became the R.E. member of the Ordnance Committee, but failing health compelled him to resign this appointment in 1892, and he died in Ireland in 1894.

He was granted the C.B. (Civil Division) in 1891, and was made F.R.S. the same year in recognition of his electrical services to the Board of Trade.

The Corps of Royal Engineers founded in his honour the Armstrong Memorial Medal, given at the Royal Military Academy for the cadet who shows the greatest proficiency in electrical science.

During the whole of his service Armstrong suffered from delicate health, and many were the stories of the treatment and nostrums he tried from time to time, while his affection for fresh air was a continual source of astonishment and admiration to his subordinates at the War Office.

training in January and February, it having been found that these months were most convenient to the men of the seafaring class who had been recruited for the local Militia.

In February the 28th Company went to Gravesend for the same purpose, and this left only M Company at Chatham to form the Submarine Mining Battalion and to find the trained men for the Submarine Mining School and the regimental duties connected with the large number of men under instruction. It was therefore necessary to detach a section of the 28th Company, under an officer, and to borrow an officer from Sheerness to carry on the work at Chatham.

The battalion organization was therefore failing at this station also, as soon as the demands for increased submarine mining training and work necessitated the companies being permanently quartered at their defence stations.

In October Major Renny-Tailyour relieved Lieut.-Colonel F. R. de Wolski as Commanding Engineer in New South Wales.

In November Major A. T. Preston gave up the appointment of Instructor at Gillingham and was ordered to Bermuda.

It had been practically decided by this time that the arrangements for instruction would be re-organized, and Capt. Roberts was appointed to act as Instructor while the details were considered at the War Office.

Major Preston had been in charge of the School for 5½ years, and though towards the end of this time the turn-out of trained officers and men had failed to keep pace with requirements, this was rather due to the unexampled rapidity with which the service had expanded than to any defect in the organization of the School. Of a retiring disposition and somewhat reserved, except to his intimate friends, Preston hardly got the full credit for the good work he accomplished. But those who knew him well found under his reserved exterior a vast fund of general knowledge, an unfailing good temper, and a high standard of professional attainment.

In November the Humber Volunteer Corps was disbanded and replaced by a Militia Corps, the local conditions of work being more suited to Militia conditions of training.

It is interesting to note that the establishment of the Submarine Mining Service at the end of 1891 was approximately :—

Regulars.—92 officers (including 4 Quartermasters) and 1,272 other ranks.

Militia.—63 officers and 1,263 others.

Volunteers.—1,806 all ranks.

Natives.—240 all ranks.

Local Militia.—120 (at Bermuda and Malta), but these were not actually formed till later.

CHAPTER IV.

HISTORICAL.—4TH PERIOD—1892-1905.—MATURITY.—DEVELOPMENT OF THE ELECTRIC-LIGHT SERVICE.

THE fourth and final period of the history of the Submarine Mining Service begins with the reorganization and development of the Submarine Mining Schools. It also includes the introduction and development of the Brennan torpedo, while it coincides with a gradually increasing interest by the Navy in coast defence questions, in the course of which they took charge of the boom defences and organized the signalling arrangements of our coasts; while for some years a party of Marines took charge of the mining defence at Esquimault.

During this period the development of the mining work was rather in the detailed improvement of methods and the gradual simplification of patterns and procedure than in any new departure, though a good deal of work was done with patterns of boat mines, which in conjunction with wire rope obstruction would be effective against torpedo craft.

At the end of this period the efficiency of the submarine mining work had reached its zenith; not only was there a remarkable absence of casualties in the minefields when laid, but the state of the organization was such that at every port throughout the Empire an effective mine defence could have been laid out within 24 hours of the outbreak of hostilities, and the whole would have been completed in three days.

There was very little movement of units, the only noteworthy change being the formation of the 48th Company for service at Esquimault in 1900.

Of the officers mostly concerned with the work, mention may be made of R. M. Ruck, Penrose, Rainsford-Hannay, Burn-Murdoch, and Dumbleton, at the War Office; Carr and Baker Brown, Vidal and Dumbleton, Boyd and Lloyd, at the three Schools; Burn-Murdoch and Le Breton-Simmons, at the experimental station; H. E. Tyler, A. M. Stuart, and H. M. Wade, in the inspection branch at Woolwich, with H. E. Rawson and Druitt, as Secretary, R.E. Committee.

But perhaps the most remarkable development was the increase of the electric-light defence for use against torpedo craft at night.

Although defence electric lights had been tried experimentally as early as 1871, and had taken practical shape in 1880, their use at first was limited to the illumination over minefields in connection with the firing of observation mines, and in the defence by gun fire against countermining, creeping, and sweeping; the lights were so used at the operations in 1886 and 1887, and by about 1890 some 50 lights, many of low power, had been provided for the various ports.

From 1889 to 1892 a most valuable series of experiments with various arrangements of electric lights were carried out at the Isle of Wight, the work devolving on the 22nd Company, under Capt. C. V. Wingfield-Stratford.

The result of these experiments was to develop considerably the arrangements for dealing with attack by torpedo craft, involving a large increase both to Q.F. guns and defence lights.

This increase naturally caused demands for an increase of *personnel* to man the extra defences, and this led to an interesting discussion as to which Corps—Artillery or Engineers—should provide the *personnel* for the lights.

The details of this discussion are dealt with in Chapter V., but generally speaking it went on the following lines.

The Artillery argued that lights were used for two distinct purposes, (1), for the illumination and protection of the submarine minefields, and (2) for work with the guns of the defence over areas which would be generally in front of the position of the mines. They therefore suggested that though the submarine miners should continue to work the minefield lights, the Artillery should take over the lights for the gun defence.

The Engineers argued, on the other hand, that there was in practice no hard-and-fast line between lights used over minefields and those for other forms of gun defence, that the arrangements for producing the electrical power for both purposes were often contained in one engine room, that the production of electricity and the manipulation of the lights were essentially Engineer services, and that only confusion and duplication of effort could result from their division between two different branches of the Army.

The question was further complicated by the changes which were then being made in the Artillery organization by the separation of the officers into separate branches for Fortress and Field Artillery.

Opinion was fairly evenly divided, but eventually, largely owing to the influence of H.R.H. the Duke of Cambridge, it was decided by 1891 that the electric lights, at any rate at all ports where there were mines, would be in charge of the Submarine Miners.

The position at the beginning of 1892 was thus—that a large increase of *personnel* would be required in the immediate future, that the instruction in electric lighting would have to be considerably extended, while the Submarine Mining School at Gillingham had already proved hardly capable of turning out the numbers required for the submarine mining work.

Up to this time electric lighting had been treated as rather an extra subject for submarine miners, and the higher instruction of all officers and certain of the men was carried out at the Electrical School in St. Mary's Barracks, and not at Gillingham.

But neither at Gillingham or at St. Mary's did the instructional plant include any fully equipped defence lights working over water in the method required for service, and neither was capable of much greater expansion. It was therefore necessary to look elsewhere. There was already in existence at Gosport the nucleus of a school used for experimental work and rough-water training of officers and men. There were also good facilities for mining work all the year round, and the position in our greatest fortress at home would place the School in touch with the best naval and military opinion. But the accommodation was not unlimited, and it was specially desired that the new organization should not be unwieldy or involve much initial expenditure on buildings.

The next largest station was Plymouth, and this also had good facilities for mining work, while the defence arrangements were only second in importance to Portsmouth. But here also accommodation was limited.

It was therefore decided after considerable discussion to have three distinct schools of submarine mining at Chatham, Portsmouth, and Plymouth, and effect was given to this decision on 16th May, 1892.

The details of this reorganization are dealt with in Chapter VII., and took a little time to develop, but the following points are of general interest.

Each school was self-contained, that is, it instructed all officers, N.C.O.'s, and men sent to it through the necessary courses, except that all men for training as Brennan workers, divers, and instrument repairers were sent to the Chatham school.

The instruction of officers was withdrawn from the Chatham school and divided between Portsmouth and Plymouth.

At the two latter stations the school work was combined with the defence duties, one set of officers and men being responsible for both.

At Chatham there were no defence duties, but the School was attached to the School of Military Engineering, and the Chief Instructor remained a member of the R.E. Committee. To regulate the supply of drafts and other purposes, all the stations at home and abroad were divided into three groups, a group being affiliated to each of the schools.

Local establishments were allotted to each station instead of the old uniform establishment of 62 N.C.O'.s and men. By this change each station got a unit with the exact number of men required for the local work. All movement of units was stopped and transfers were made by drafts only.

All these details were not elaborated at once, and took some time to evolve, but good-will and hard work eventually overcame all obstacles, and the new organization proved remarkably efficient. It was also very economical, as the combination of defence and instructional duties enabled the work to be carried on with the minimum of staff, while the extra highly trained officers and N.C.O.'s allotted to the schools, although few in number, proved a valuable addition to the *personnel* available for defence.

The experimental station was at the same time removed from Portsmouth to Pembroke Dock, and the officer in charge of the submarine mining defences at the latter station became the experimental officer.

The first officers appointed under the new scheme were Capt. G. A. Carr, who was specially brought home from Bermuda as Chief Instructor at the Chatham School, Capt. W. Sealy-Vidal from experimental officer, who became Chief Instructor at Portsmouth, and Capt. M. A. Boyd as Chief Instructor at Plymouth.

The Assistant Instructors were Capt. H. B. Roberts at Chatham, Capt. W. Baker Brown at Portsmouth, and Capt. W. G. Lawrie at Plymouth, while Lieut. E. C. Seaman remained at Chatham in charge of the instruction in Brennan torpedo work.

The new experimental officer was Capt. P. Burn-Murdoch.

It was one of the objections urged against the separation of the schools that there would arise a diversity of practice and training which would be harmful. But in fact, though such diversity did arise, the annual visits from Headquarters and inofficial interchange of views between the different instructors entirely prevented any harm arising, indeed, the difference did often result in new methods being tried and introduced which produced great improvement.

A notable example was the changes in the instruction in water work introduced by Capt. Sealy-Vidal. Prior to 1892 the instruction at Chatham had been mainly individual, that is, each man had been carefully practised in the actual details of the work he would have to do; but combined practice was limited to the drill of a squad in the various operations of preparing and laying out the mines.

Separate gear was kept in the drill sheds for practice in connecting up, and such mines were never removed from the sheds, a second set being kept on the boats for practice in laying out. Similarly, testing was practised mainly with apparatus representing mines and only partly with real mines on the water. Such a system had answered admirably in the early days, when a very large number of men had to be pushed rapidly through a course with a very small nucleus of trained men, but it was apt to become monotonous and to be rather the A.B.C. of instruction than a complete course. This was always recognized, and the institution of the rough-water course at Portsmouth, at which all the work was done on defence lines, was intended to meet this difficulty as far as possible.

But in addition to these objections, the development of the Submarine Mining Service had caused great importance to be attached to rapid laying and the co-operation of all the various parties employed both ashore and afloat.

Rapidity and combination had been for some time put forward by the War Office as the main objects to be secured by stations, coupled of course with accuracy and efficiency of work, and the annual practices at stations had been arranged with these objects in view.

Vidal decided that he would extend these same methods to the instruction of officers and men.

Instead of continuing the instruction in any detail until the squad was ready for examination by an officer, as had been done previously at Chatham, he put his classes, after a very short period of individual instruction, to combined work by squads, each squad performing all the operations required for preparing, laying out, and raising the mines.

At first this system was not extended to the electrical work, mainly because it was thought that testing each mine would unduly delay the classes on the water. In fact at this time, though the electrical arrangements were very complete, the rapid use of them had not been developed nearly to the same extent as the other work ashore and afloat. This was due partly to a great deficiency of electricians qualified to carry out the tests, and partly to a difficulty with the boats used at the various junction boxes in the water to make the joints between the mine cables and the main cables from the shore. Not only had these joints to be well and carefully made under conditions peculiarly conducive to *mal-de-mer*, but it was an essential feature of the electrical arrangements that the cable from the shore to the box should be tested before any mines were connected, and that each mine should also be tested before it was permanently connected to the system. This involved telephone communication between each boat and the shore, and a well-trained man in the boat to make the temporary and permanent connections.

The difficulty as regards trained electricians was in process of solution, as the increased numbers required for electric-light work gave sufficient trained men to each station to enable one to be allotted to each junction-box boat, as well as providing extra hands for the test rooms.*

* The great economy of combining submarine mining and electric light into one service will be evident from this example, as these extra men, required only for two or three days while the minefield was being laid out, were then employed as reliefs for the electric-light *personnel*.

Vidal surmounted the difficulty of the supply of junction-box boats by hiring suitable boats from the local fishermen. Hitherto the work had been done in the row boats attached to all submarine mining stations, cutters, gigs, and dinghies. These were supplemented by a few specially built boats of a pattern which had been evolved at Chatham for the quiet waters of the Medway, but were hardly sufficiently seaworthy for rougher water. But the total number proved quite inadequate and none of the patterns were suitable for work in bad weather. Vidal pointed out that many local types of fishing vessels used for trawling, etc., were specially adapted both in size, build, and equipment for the purposes of junction-box boat work, that their sails would usually enable them to move from place to place and to get to and from the minefield without calling on the steamboats for a tow, while a masthead tackle was well adapted for lifting the junction box with its streamers of heavy cable. A trial was made, and gradually at each station there developed an auxiliary fleet of sailing boats, each with a crew of one or two men, who managed the boats, and as they gained experience helped materially in handling cables and boxes.

As work afloat increased in efficiency it was found necessary to provide three or four such boats to attend on each laying-out vessel, and as sometimes two or even three vessels might be laying mines simultaneously, a test room might be in communication with 8 or 10 boats, of which perhaps half would have mines ready for testing.

At first Vidal himself despaired of keeping the electrical testing up to time, and followed the naval system of laying the mines without tests and trusting to careful preparation to give a good minefield. But in 1892 Capt. Baker Brown, assisted by S.M. Harrison, tackled the problem, and partly by small changes in the test-room methods, partly by an increase in the test-room staff, but mainly by careful drill both ashore and afloat, succeeded in keeping the rate of testing well in advance of the work on the water.

Similar action had been taken at other stations, and in a very short time rapid interworking of all branches had become the usual method of work.

The history of the Brennan torpedo is dealt with in another chapter, and there was no question from its introduction that it would be in charge of the Submarine Miners. It was finally installed at seven ports.

It proved in good hands a most efficient weapon and at the same time a most fascinating study.

Reference may be here made to an attempt made in 1888 to use Royal Marine Artillery for the garrisons of some of the smaller ports in the Colonies.

For some years a small party in and out of Parliament, led by Sir J. C. Colomb, M.P., himself an old Marine officer, had made repeated attempts to get the garrisons of some of the smaller ports abroad transferred to the Royal Marines.

In support of this view it was argued that Marines were good gunners, that their nautical training would specially fit them for the mining work, that they were accustomed to work in small detachments, and that they would, if employed in garrisons, act as a valuable reinforcement for the ships on the station.

The arguments against their employment were that it would introduce an undesirable duplication of responsibility, as the Admiralty had no machinery for the construction of forts and batteries, and would have to obtain from the War Office the guns, mines, etc., required for the defence.

It was however recognized that the employment of Marines would relieve the Army of the care of several small detachments whose maintenance, inspection, and relief would be troublesome to arrange under military routine.

By 1888 provision had been made for most of the larger Colonial ports abroad, but the three small stations of Esquimault, Thursday Island, and King George's Sound remained without garrisons.

Mr. Stanhope, the Secretary of State for War, determined to try the experiment of using Marines at these stations, and brought the matter before the Cabinet in August, 1888. The result was thus recorded at the War Office :—

"The Admiralty undertake all the responsibility for such small white garrisons as may be necessary for the above places."

But on referring to the Admiralty for confirmation of the above, the latter repudiated all responsibility and said that they had only agreed to supply certain men from the Royal Marines if the whole expenses were paid by the Colonies concerned.

After some discussion it was eventually agreed that certain detachments of Royal Marines should be detailed by the Admiralty. Among these were included 15 N.C.O.'s and men for submarine mining duties at Esquimault and five for similar duties at King George's Sound, to whom were subsequently added two officers for each station.

As the mines it was proposed to employ were of War Office pattern, it was necessary to send these detachments to Chatham to be trained, and in order to provide for casualties a party of 2 officers and 31 men were detailed accordingly in June, 1889.

The men went through the ordinary submarine mining recruits' course and selected men went through the various special courses. Four officers went through the full officers' course in 1890.

These various courses took time to complete, but by the end of 1890 the training was finished, and as the negociations with the Colonies were still in progress, the detachment was sent to Gosport and attached to the Submarine Miners there to gain experience in their new duties.

Meanwhile a long correspondence had taken place between the War Office, Admiralty, Colonial Office, and the Colonies concerned. In the course of this it was decided to withdraw the mine defence for King George's Sound, and the discussion then centred on the question of Esquimault.

Finally it was agreed that the Canadian Government would provide a lump sum towards the construction of the necessary defences, would pay the whole cost of the Marine *personnel* and a portion only of other expenses. The War Office had to find the rest of the money, construct the fortifications, and purchase and send out the necessary stores.

The Admiralty lent the officers and men, but disclaimed all financial responsibility.

This correspondence took till 1893, and in the middle of that year the detachments for gunnery and mining duties finally left for their new station.

The submarine mining detachment had during this time been employed at Gosport under Sealy-Vidal, and took part in the annual practices and much of the instructional work of the newly-formed school. They proved individually remarkably efficient, though it must be remembered that they were to some extent picked men of a picked corps, serving on a long engagement under favourable pension rules.

When they arrived at Esquimault the defences were not commenced or the mining buildings erected, but there were some old barracks, not very completely equipped, which had been handed over by the Canadian Government. Had the detachment been drawn from the R.E., the officers and men would have at once been able to set to work to improve the barracks and commence the defences. But the Marines not being trained for these duties, it was necessary to send a special officer for the Engineering work, and as all the money was being provided through the War Office, this officer necessarily corresponded with England through the General Officer Commanding the Regular troops in Canada.

It was inevitable that such an arrangement should give rise to friction, but it dragged on for some years, during which no mining was actually done, until it was decided in 1899 that the War Office would provide the whole garrison.

A new Submarine Mining Company, the 48th, was thereupon formed in 1900 and sent out to the station. The Marines then rejoined their headquarters.

Two things seem evident from this experience. First, that the Admiralty cannot undertake the responsibility for the defence of any port until they have a complete organization for dealing with all details. Secondly, that a divided responsibility gives rise to the most interminable correspondence and delay on every point which arises and proves in practice quite unworkable. As a matter of convenience to the War Office, the extra trouble and expense of looking after these small garrisons from the first would have been amply repaid by the saving of the correspondence and delay caused by having to consult with another department of Government on every detail The small numbers required, which took over two years to train, could have been found by the R.E. at a few hours' notice, and when the orders to form the 48th Company were finally issued, the company was formed complete with different ranks and trades in the course of a few days only.

In 1892 the Inspector of Submarine Defences published the first of a series of Annual Reports, giving a summary of the results of the previous year's work. These not only furnish now valuable historical data, but at the time proved a great incentive to stations. **1891-92.**

In the first report, which dealt with events to the end of 1891–92, the most important, in addition to the proposed decentralization of instruction, was a reduction in the strength of the Militia, which had been gradually increasing in numbers with a view to their employment in guard boats, and the formation of a special section of the Reserve for submarine mining work. This section was formed to bring in the fairly large class of long-shore men to be found at most ports, who were, as a whole, reluctant to enlist in the Militia on account of the drill and military duties, but had, when engaged as civilians, proved very efficient submarine miners. Their services were now secured by enlisting them into the R.E. for six years' service, and converting their service the same day into Reserve service. They did very little military drill, were clothed in working clothing only, and when possible lived in their own homes. At many ports they proved a great success; at others it is doubtful if the Militia organization was not more suitable.

A beginning had been ordered, when a Militia Corps was formed at Malta with an establishment of 60 all ranks, and arrangements were being made for a similar corps at Bermuda, but pending this, the civilians who had been permanently engaged at that station and Halifax were retained.

At Hong Kong it was at last decided to enlist the Chinese civilians who had been employed for some years, and a corps of 50 men was raised in a short time.

Considerable progress was made at this time with the fleet of submarine mining vessels, the early launches—which were 42′ naval pinnaces fitted with boilers and engines—having worn out. Ten were replaced in 1891, and in addition two new steamers were added.

There was little change in patterns of stores, the most important experiments in progress being with detonators and fuzes, which still proved wanting in reliability, especially after storage for two years or upwards.

1892. The report for 1892 showed that the establishment of the Militia—in spite of the formation of the Humber Corps, which had been substituted for Volunteers—had been reduced to 715 N.C.O.'s and men.

A summary of the whole defences contained in this report shows that at this date there were submarine mining defences at 28 ports, with an establishment of 31 miners, 31 launches, 56 other suitable vessels which could be hired, 45 test rooms, 31 observing stations, and 47 electric lights.

In appendices attached were given extracts from some of the principal practice reports from stations. Two were noteworthy as giving some evidence of the progress which had been made, and as a starting point by which the improvements in the next decade can be judged.

At Hong Kong, under Capt. H. N. Dumbleton, a strength of about 100 of all ranks, with two laying-out vessels, laid out 103 mines of the defence in about 22 hours (actual work), extending over three days. The conditions were a reproduction as exactly as possible of those in time of war. The order to lay out was a surprise and was given at 3 p.m.

The result of the tests showed 8 E.C. mines and 12 observation mines were unserviceable. They were put right in a few more hours' work.

This was a very good record, though it was much bettered in subsequent years. The system of large deck loads had not reached the station, and this delayed the water work, while it must be remembered that less than half the men were Europeans.

In the following month at Spithead the 4th Company, under Capt. Sealy Vidal, with 175 men, two vessels and a launch, laid 100 mines in a day of 11 hours, the main cables having been previously laid and the first loads being prepared and embarked overnight. Large loads were used, and under this system one vessel, the *General Skinner*, laid 52 mines in four trips in 9½ hours. Owing to the want of sufficient J.B. boats, a proper system of tests was not taken.

It will be noticed that this record showed a great improvement as regards speed not only on that of Hong Kong but indeed on all previous results, a speed of 30 to 36 mines a day per vessel having been thought very good work.

Twelve years later, in 1904, at Hong Kong, Major A. C. Painter laid out 110 mines in six hours, the first loads of mines having been prepared and embarked in two hours' work the previous evening. There were two laying-out vessels in addition to several launches for towing, and a small fleet of some 10 J.B. boats.

All mines were in good order when laid except two.

The rate of laying per vessel would work out at over 90 mines a day of 10 hours.

This record was nearly reached at many stations, but it is doubtful if it has ever been exceeded.

In 1893 the most important question discussed was the first report **1893.**
of the joint Naval and Military Committee on Defence.

As will be seen in the earlier chapters, all important changes in defence matters had always been considered by committees of naval and military officers, and there had always existed a Defence Committee composed of the higher officials at the War Office and certain naval officials, who considered all questions of general policy.

But in 1892 this procedure was given rather more definite shape, and a special committee was formed under the Presidency of the Under Secretary of State for War, with four naval and four military members selected from the senior officers at the Admiralty and War Office. A naval officer was at the same time appointed to the War Office as Naval Adviser and became the naval secretary of the Committee. The military secretary was a member of the staff of the Inspector-General of Fortifications.

This committee first assembled in 1892, and at once began to consider certain principles on which the scale and method of defence should be based. These had a very important bearing on the whole of our future policy.

The result of the regulations drawn up by this Committee was to place upon the Admiralty the full responsibility for the whole system of mine defence. It was open to them to object to any minefield, to suggest changes in the arrangements (a right they often exercised), and, if necessary, to instruct their local representatives to object to any minefield being laid out without previous reference to England.

But on the whole the arrangement, though somewhat anomalous, worked well, and the result of the revision of mine defences was to provide a strong defence at the principal harbours, with practically no interference with friendly traffic. Of course in time of war there must be some investigation of vessels entering, but this is in no way caused by the mines, and as a fact the regulations on this head have been made more stringent since the mine defences were withdrawn in 1904.

To adapt these principles to the actual defences a strong sub-committee was formed, with Major Ruck as Secretary, which went into the details of all defences, and modified minefields where required.

1894. The report for 1894 begins by referring to the fact that a change had been made in War Office procedure, by which all electrical questions, such as telegraphs and telephones, lightning conductors and barrack lighting, were dealt with from the technical aspect by the Inspector of Submarine Defences.

At stations the submarine mining officers and men were frequently employed on such services, but there was a separate establishment of men for telegraph and telephone duties, and the establishments of stores were kept quite distinct from those for the mine defences.

During the past three years there had been a steady yearly augmentation of the establishment of the Regular units of about 30 to 40 men each year. This was of course for electric-light work.

The trainings at stations had increased in efficiency, and from 1891 the length of the annual practice had been extended from three to four months, and been supplemented by weekly or monthly practices during the remainder of the year, at which some part of the defence minefield was laid out in accordance with the authorized scheme of defence.

The Brennan installations were approaching completion, and a reference was made to experiments on the floating installation—the *Sir Howard Elphinstone.*

A very important experiment was carried out at Stokes Bay in the last months of 1894 with electric-light engines, using paraffin oil as a fuel. Two patterns were experimented with, made by Messrs. Priestman and Messrs. Hornsby. Both proved good, but the first had an electric ignition which occasionally failed. The Hornsby type however proved very simple and reliable, and was eventually adopted into the Service.

This change is a great landmark in the progress of defence electric lighting. Prior to this date all installations had obtained their power from a steam boiler, requiring generally two to three hours to get up steam, considerable accommodation for boilers and engines and a numerous *personnel.* The oil-driven engines could, it was found, be started in about 20 minutes, and required only half the number of men. They were also cheaper and easier to repair.

An experiment carried out by the Ordnance Committee at Milford Haven is recorded. This was the explosion of a charge of 250 lbs. guncotton against a paddle steamer of 500 tons, the *Harpy.* The results confirmed the experiments carried out against the *Oberon* in 1873.

In October, 1894, the Submarine Mining Service suffered a great loss by the serious illness and death of Capt. Sealy Vidal. A bad attack of enteric was followed by consumption, and after trying all possible remedies he died suddenly at Teneriffe in January, 1896, at the early age of 35. Good at all outdoor sports and particularly tough both in body and mind, he will be specially remembered in connection with the Submarine Mining Service for his remarkable ability as a sailor and waterman.

Not only could he hold his own with any naval officer on the water, but could also take his place with the hands on the best of our racing yachts. It is said that he once spent a summer holiday as a deck hand in the forecastle of one of the larger yachts during a tour of the regattas in the south of England, and on another occasion with a friend he took a small 5-tonner from Dartmouth to Plymouth in the teeth of a south-westerly gale, and had the barren satisfaction of sailing over the course alone, all his competitors having refused to face the weather.

He brought to bear on the submarine mining work all the knowledge and methods of the skilled seaman, and some of his improvements have been already referred to. If rather impatient of mediocrity, he was capable of getting the maximum amount of work out of subordinates once they understood his methods, and when any specially arduous day's work had to be tackled was always ready to lead the way by personal example as well as precept.

The report for 1895 opens with a general recapitulation of the **1895.**
principles governing mine defences, as modified by three years' experience and correspondence with the Admiralty.

It seems desirable to quote a few paragraphs in order that the relations between the Admiralty and the War Office at this date may be fully understood.

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"The system of friendly channels should be adhered to. . . . When a navigable channel is to be contracted or in any way interfered with by mines, the assent of the Admiralty in each case should be first obtained."

"The nature of the mines to be used will be determined by the War Department, by whom however all plans of the Mine Defences will be communicated to the Admiralty before final adoption."

"Admiralty concurrence should be obtained before any mines are laid in ports at home. Very great importance is attached to the observance of this rule, as in the general interests of the country, which are inseparable from unrestricted traffic and safety of navigation, the necessity for laying mines at ports would be governed by the power of the Navy to keep the coast clear of the enemy. Mines should be laid down by order of the senior military officer after Admiralty concurrence has been obtained through the senior naval officer at the place, and the conditions upon which the mines should be made active must be decided in the same manner."

"The regulation of traffic in and out of defended ports rests with the senior naval officer."

o o o o o

"All boom defence of naval ports will be provided and worked by the Navy, but the guns, electric lights, and mines for the defence of the boom are to be provided and worked by the Army."

"While undertaking the above duties the Admiralty cannot station vessels for the protection of ports."

o o o o o

The reference to booms at naval ports was the result of a series of experiments carried out by the officers of H.M.S. *Vernon* in 1891 and subsequent years with boom defences.

Experiments were carried out with two different types, one of which was identical in pattern with that designed by the Royal Engineers and tried in 1880 and 1886. It was a ladder boom of large baulks fitted with spikes, but improved by the substitution of steel-wire hawsers for the chains formerly used, and by the addition of a small hawser secured by uprights a few feet above the general level of the baulks, so as to catch the funnels or masts of vessels trying to jump the boom; thus fitted the boom naturally proved effective, the spikes penetrating the bottom of attacking boats, which were also held up by the wire rope.

The second form was novel and consisted of a ladder of wire rope placed sideways, with the lower side submerged. Any vessel charging the boom would be entangled in the wire network and stopped. Experiments with these two types were continued till a first-class torpedo boat was sunk during the trials, and both patterns of boom were then adopted for alternative use at certain naval ports. To be effective both require very powerful anchorages to secure the shore ends, and if beyond a certain width the vertical type must be buoyed at intervals by gunboats or other vessels. The total expense of a boom of either pattern is very considerable, probably as much as the whole cost of a minefield for the same width of water.

Booms of course block a channel completely, and various arrangements have been tried to form a "gate" for the admission of friendly ships; but all these take time to operate and compare very unfavourably with the few seconds required to make a minefield safe by disconnecting the electrical circuits.

Extensive trials were made in this and the previous years with electric lights at Plymouth under the new conditions. These proved especially interesting, and were used to guide much of the subsequent arrangement of electric-light defences.

In May, 1895, Capt. Lawrie was succeeded as Assistant Instructor at Plymouth by Capt. F. L. Lloyd.

During the absence of Capt. Vidal the work of the Chief Instructor at Portsmouth devolved on the Assistant Instructor, Capt. Baker Brown, Lieut. J. W. S. Sewell acting as the Assistant. In August, 1895, Capt. H. N. Dumbleton was appointed Chief Instructor, vice Vidal.

In January, 1896, Major G. A. Carr was appointed Instructor in Electricity at the School of Military Engineering, and was succeeded in April as Chief Instructor at Gillingham by Capt. Baker Brown. At the same time Capt. H. B. Roberts was succeeded as Assistant Instructor at Gillingham by Capt. G. P. A. Acworth, and Capt. E. H. Haig became Assistant Instructor at Stokes Bay.

It may be noted that in 1895, the minefields proposed for the defence of Dublin and Belfast were withdrawn at the suggestion of the Joint Naval and Military Committee, and minefields were provided, at the request of the Admiralty, to defend the naval anchorages at Portland and Berehaven.

The principal event of the year 1896 was the completion by Major **1896.**
R. M. Ruck of his tenure of appointment as Inspector of Submarine Defences, thus completing a continuous service of nearly 12 years at the War Office, during which time he had assisted at the formation of the whole of the modern organization of the *personnel*, the mine equipment had been extended and brought up to date, the schemes of defence revised as the principles of modern warfare were better understood, and our Navy had expanded to meet the new conditions.

The efficiency of the Submarine Mining Service at this date, and especially the way in which the organization had been adapted to meet the requirements of ports in all parts of the world, are a lasting testimony to the value of his guidance.

He was succeeded as Inspector of Submarine Defences by Major C. Penrose, and Major P. Burn-Murdoch became Assistant Inspector.

A revision of the vocabulary of stores becoming due in 1896, advantage was taken of this opportunity to revise the vocabulary of all submarine mining and electric-light stores, and at the same time old patterns were discarded and certain new patterns and stores introduced. Considerable attention was also given to the standardization of screw threads first started by Capt. H. E. Tyler, and sets of screwing gear were issued to stations for repairs. The work of the revision of stores fell mainly on Major G. A. Carr, Capt. A. M. Stuart (I.R.E.S., Woolwich), and Capt. Baker Brown, and in this and the subsequent years all the mining gear was passed in review, and new patterns of most of the mine cases, apparatus, and electrical stores were introduced. The greatest changes were the substitution of a steel framework for the wooden box, which held the charge in a spherical mine case, and the design of a cylindrical ground mine case with a steel loading frame, heavy cast-iron ends, and no cement lining. Among other things the pattern of shutter apparatus, arranged by Malcolm & Armstrong in 1873, came up for improvement.

A small change made at this time was noteworthy. Although all detonators and fuzes for both naval and military service were made at Woolwich, and both used similar patterns, the outside dimensions of the detonators varied slightly for the two services, and made it necessary to keep two patterns of guncotton primers, one for each service. At the instance of the military officers this was changed, and one set of dimensions was adopted for all future naval and military stores of this description.

1897. In April, 1897, Capt. C. B. Collins succeeded Capt. E. C. Seaman as Assistant Instructor for Brennan work.

This year saw the introduction of parabola-ellipse lenses for electric lights, and the beginning of the improvement of the Brennan by the substitution of thicker wire.

The Corps of Electrical Engineer Volunteers was being formed during this year.

This corps was one of the results of the extension of the defence electric lights. It has already been shown that the regular forces had been very considerably increased in number to provide *personnel* for the extra lights which were being approved. But large as was the increase in Regulars, the number of lights increased faster than men could be provided and trained, while an increase of Regulars up to the full number required would have thrown a very heavy charge on the estimates. Under these circumstances the possibility of training the auxiliary forces to take a share of this duty had to be considered. At ports where there was an auxiliary Volunteer corps the solution was easy, as the corps, in addition to the very high average of intelligence and education in all ranks, included a good proportion of mechanics of just the type required for the electric-light work. It was therefore only a matter of adjusting establishments to requirements and of starting the necessary training.

But in the ports where the auxiliary corps was on a Militia basis, which included about three-quarters of the whole number of lights, the problem proved more difficult. The Militia officers were quite equal to the responsibilities of the additional work, indeed with their two months annual training were able to get a thorough grasp of the defence requirements. But the rank and file had been selected mainly for proficiency in water work, and did not include many tradesmen. As a whole therefore they were not up to the standard required for electric light, and only a small proportion could be trained for the work. The special Submarine Mining Reserve proved even less fitted.

Under these circumstances it was necessary to look outside the Submarine Mining Service for the necessary assistance, and Major Ruck had been for some time in consultation with Professor Hopkinson and other leading members of the electrical profession, with a view to the formation of a corps to undertake these duties. After some discussion the conditions of service of such a corps were formulated; a few enthusiastic gentlemen, under the guidance of Professor Hopkinson, started recruiting, and gradually a headquarters was obtained and a valuable addition made to the auxiliary corps of the Submarine Mining Service.

On 1st January, 1898, Major Penrose, who had been six years at **1898.** the War Office, was succeeded as I.S.D. by Major F. Rainsford-Hannay.

In 1898 the establishment of N.C.O.'s and men (Regulars) was raised by another 150 men to a total of 1,707, and there were 97 R.E. officers employed. There were also 282 men of the Special Reserve, and 58 officers and 766 men of the Militia, including the Bermuda Militia, which was still in a state of suspended animation.

The establishment of Volunteers was 88 officers and 1,221 N.C.O.'s and men, of which 73 officers and 1,150 men were efficient.

The natives with the four local companies numbered 230.

The total strength was thus 243 officers and 4,206 other ranks.

A revision of the *Submarine Mining Manual* was taken in hand this year by Capt. Baker Brown, aided by the Chief Instructors at the other schools. Parts I. and II. were completed and issued in the course of a year or two, but the revised Part III. for various reasons had not been issued when the service was broken up.

Meanwhile another difficulty had arisen in connection with electric-light *personnel*, and that was the provision of Regulars to take charge of the lights at the ports where there were no submarine mines. The ports affected were Gibraltar, St. Lucia, Sierra Leone, Cape of Good Hope, abroad; and Dover, Scilly Isles, and Lough Swilly, at home; there were thus a considerably larger number of lights abroad than at home.

The Submarine Mining Branch at the War Office suggested that the simplest way to find the *personnel* would be an extension of the Submarine Mining Service; but to this it was objected that such *personnel* at ports without mine defence would be unable to maintain their efficiency in their special duties. Also there was by this time in each fortress abroad a company or half-company of the R.E. fortress service, who were employed in building fortifications, etc., in peace, and in war were available for the ordinary engineer services of entrenching, water supply, and sanitation. It was thought that these might be drawn on, without any increase of cost, for the electric-light work.

This last view was adopted, and the men for the electric lights at Gibraltar, etc., were trained at the Electrical School, S.M.E., and drafted in due course to the fortress companies at the various stations.

It cannot be said that the arrangement proved a success, and this is not surprising when it is seen that it violated several of the essential principles on which the Submarine Mining Service had been built up.

There was, for instance, no proper proportion between the numbers at home and abroad, so that trained men who had completed a tour abroad were transferred to companies at home which were not employed on electric-light duties, while new men had then to be trained to fill the vacancies abroad, the whole producing a very large annual wastage and throwing heavy work on the Electrical School.

Also the officers of the fortress companies had not received the special training in electrical science, which was given to officers who went through the submarine mining schools, and had no previous experience of the employment of defence electric lights.

An alternative scheme was proposed about this time by the Commandant, S.M.E.—Major-General T. Fraser—based on suggestions made by Major G. A. Carr and Capt. Baker Brown, under which a considerable proportion of the so-called Fortress Service would be amalgamated with the Submarine Mining Service.

It was pointed out that the latter now undertook most of the technical fortress work, and was thus in a very real sense the true fortress service, and it was suggested that there would be an economy of units and *personnel* by forming a new fortress service which would include all the special fortress duties. The special training would include sufficient men for the submarine mining duties, another set of men for the electric lights, and others for telephones, engine driving, etc., but the ordinary training would include a sufficient grounding in all these branches of fortress duties to ensure the economical distribution of all ranks in peace and war.

This scheme was necessarily comprehensive, and was not accepted at the time by the War Office, and the outbreak the following year of the South African War made it impossible to carry out any change of this magnitude.

1899. Except the continual growth in numbers and efficiency, there was nothing noteworthy to record till the war broke out in South Africa. At first the effects were only visible in the withdrawal of some officers and men for service in the field, but as the strain increased and demands for reinforcements became pressing, increasing drafts were made on the submarine mining *personnel*, especially for duties where their training might prove useful. Thus the 46th Company, raised for steam transport, was largely recruited from the Submarine Miners, who were also drawn on for telegraph duties, and later three search-light sections were formed, two from Submarine Miners and one from the Electrical Engineer Volunteers.

Later still one of these sections was formed into a Field Troop under Capt. D. H. Ridout, and once the men had learnt to stick on their horses, it did excellent service.

The places of officers and men were taken by officers from the Militia, and by calling out a part of the 1st Class Army Reserve, while in 1900 the whole of the Submarine Mining Militia Corps were embodied for about six months, and the special Submarine Mining Reserve was called out.

When the Volunteer Force was invited to send detachments to the front, several of the Submarine Mining Corps responded to the call, and all corps participated in the increase of establishments, which was granted in consequence of the wave of enthusiasm which ran through the country.

Of individual submarine mining officers in special employment, Major Burn-Murdoch formed the 47th Company in January, 1900, and took it out to Cape Colony, being replaced in the War Office by Major A. H. Randolph from the retired list. In February Capt. F. L. Lloyd went to the front with the E.E.V. search-light detachment and Capt. Acworth for special service. Lloyd was replaced as Chief Instructor by Capt. E. H. Haig, and Acworth by Lieut. G. Durnford. Haig's place at Portsmouth was not filled till January, 1901, when Lieut. J. R. Garwood was appointed Assistant Instructor.

On 1st February, 1901, Major Rainsford-Hannay, on promotion to **1901.** Lieutenant-Colonel, was made Assistant Inspector-General of Fortification, and was succeeded by Major H. N. Dumbleton. Capt. C. B. Collins, the Assistant Instructor for Brennan, who had been attached to the Brennan Factory for experimental work, became Chief Instructor at Portsmouth.

On 1st April Major Baker Brown completed the tenure of his appointment at Chatham, and was succeeded by Capt. G. P. A. Acworth.

On the same date a change was made in the instruction in Brennan work. It had for some time been felt to be anomalous that officers and men under instruction in the special details of this branch at Chatham, had to do all their practical training with the defence installation at Sheerness, so that this important element of the defence was practically taken out of the hands of the local officers. Also the success of the two schools at defence stations led Major Bakei Brown to suggest that a similar combination at Sheerness might give greater efficiency, with some economy of officers and men. Arrangements were therefore made to withdraw the instruction in Brennan work from the Chatham School and to start a new school at Sheerness. The senior submarine mining officer at that station was appointed Instructor in addition to his other duties, and one of his subalterns was given extra pay for assisting with the instruction.

At this time there was a good deal of unrest as regards the future position of the School at Gillingham. The Navy, in pursuance of their policy of substituting barracks for hulks at the larger ports, had constructed large new barracks at Chatham, and to provide for their extension had asked the War Office to hand over St. Mary's Barracks. These barracks were at the time used by the Submarine Miners and by other R.E. officers and men, and included also the buildings of the Electrical School, S.M.E., so that it was necessary to re-provide this accommodation before the site could be transferred to the Navy. In the case of the Electrical School there was not much doubt; it had to remain at Chatham and near the other buildings of the S.M.E. There was no suitable building available, and a new one had to be provided. The Navy therefore promised the funds, and work was started almost at once. For the ordinary R.E. units it was a matter of barrack accommodation, and after several building schemes had been considered, accommodation was found by removing R.E. units to other stations.

But in the case of the Submarine Miners the problem was more difficult, as the transfer of the unit elsewhere involved the removal of the school buildings at Gillingham. On the other hand, difficulty had for some time been experienced in training the increased numbers in electric-light work at Gillingham owing to the insufficiency of plant, and though successive additions to the machinery partly met this difficulty, the facilities could not compare with those at Portsmouth and Plymouth, at each of which there were now nearly 20 defence lights available for instruction and training.

Various proposals were therefore made to move the School altogether from Chatham. It was suggested that it might be broken up and the work divided between the other two schools, but investigation showed that this would probably overload the latter. Also the Commandant, S.M.E., objected to the submarine mining instruction being entirely removed from the neighbourhood of Chatham, as he thought it undesirable that the young officers who were not selected for the full submarine mining course should be absolutely unacquainted with the principles of submarine mining.

For this reason the final proposal crystallized into a scheme to remove the Submarine Mining School from Gillingham to Sheerness.

Meanwhile Major Dumbleton had made an important change in the general training of the Submarine Mining Service by including for all ranks an elementary course of electric-light work. Henceforward all submarine miners were to be divided into two classes—Submarine Miners (A) were to be trained to manipulate the electric lamp and help in the elementary electrical work; Submarine Miners (B) were to be trained to work the oil engine, and as stokers for the steam plant, which still existed in considerable numbers.

The Electrical Engineer Volunteers had by this time grown into a large corps, thanks to the incentive given to recruiting by the South African War, and their individual qualifications were very high. But considerable difficulty was found in getting them to train at the ports to which they were allotted in peace, and they could only do a very short period of training.

Also other Volunteer Corps had expressed a willingness to assist outside their own area, so that we find by this time the Tyne Volunteers were providing detachments for Portsmouth, Portland, and Humber, and the Severn Volunteers were manning at Pembroke Dock.

The Tyne Volunteers, under their energetic commanding officer—Colonel W. Johnson, V.D., C.B.—were always ready and willing to provide detachments of men for work at any port in Great Britain, and often rendered valuable assistance in providing men for electric-light manning during combined manœuvres with the Navy or defence operations.

On the conclusion of the South African War it became possible to 1902.
complete the foreign reliefs, many of which had been suspended, and this and the following year were spent in getting the service into full working order again.

In June Capt. W. M. Pyne was appointed Experimental Officer, vice Le Breton-Simmons, and was succeeded at Plymouth by Lieut. F. W. Robertson.

In December Major H. V. Kent succeeded Major A. H. Randolph as Assistant Inspector, S.D., at the War Office.

The end of the year 1903 was rendered noteworthy by the Com- 1903.
mittee of three charged to reorganize the War Office. Among other results of this organization the Inspector-General of Fortifications was abolished and his work subdivided, the War Office work devolving on a Director of Fortifications and Works, and the Inspection on an Inspector of Royal Engineers on the staff of the Inspector-General of the Forces. The officers selected for these appointments were both ex-submarine miners, Colonel R. M. Ruck becoming D.F.W. and Colonel G. Barker the I.R.E. The staff at the War Office was at the same time reorganized and reduced; among others the appointment of Assistant Inspector, S.D., was abolished, and also the extra pay of the Experimental Officer.

The Joint Naval and Military Committee was broken up, and its place taken by the Committee of Imperial Defence.

Early in 1904 the Russo-Japanese War broke out, with its very 1904
remarkable development of submarine mining, both in attack and

defence of Port Arthur. To mining experts the principal lessons seemed to be the value of electrical controlled mines for defence, as compared with the mechanical system used by both sides, and the value of mines to the defence in meeting the attacks of blockers and in prohibiting the use of anchorages to the attack.

But before these results had been really known or there was any prospect of estimating their effect on future policy, the decision had been given to transfer all mine defences to the Navy, while the Army remained in charge of the electric lights.

The details of the controversy which led up to this change are dealt with in the following chapter.

In accordance with this decision arrangements were at once made to hand over the mine defences to the Navy. It was realized that this would be very difficult, as practically all electric lights were used in connection with gun defence, and with the exception of three lights only, there were no lights installed for exclusive use with mine defences, and as the submarine mining and electric-light defences were parts of one organization, the establishments were used for both purposes, and such buildings as offices, stores, and barracks were common to both.

The procedure was however much simplified when it was found that the Navy only wished to take over the actual mines and apparatus, with the buildings which contained them, and the greater part of the vessels.

These latter were re-named and distributed for various naval duties, and such of the mining stores as could not be converted into blockade mines, including the whole of the electrical plant, were broken up under the steam hammer or sold by public auction.

In this inglorious manner ends the history of Submarine Mining in the British Army.

The detailed steps taken to bargain with the Navy for what they did not require and to reorganize the shattered service are recounted in Chapter XV., which will show how it rose Phœnix-like to commence a new and, it is hoped, useful life as the electric-light portion of a reorganized Fortress Service.

This chapter can be fittingly ended by a statement of the Establishments of the Service on 1st April, 1904, which may be called the

LAST ROLL CALL OF THE SUBMARINE MINERS.

Regulars, R.E. ...	Officers*	... ...	95
	Other ranks	S. Staff	191
		Others	1715
			2,001

* Including 16 belonging to the Coast Battalion and 15 Quarter-Masters.

	Brought forward	2001
Militia, R.E. ...	Officers	58
	Permanent Staff	59
	Other ranks	751
Volunteers, R.E.	Officers	122
	Other ranks	1805
Reserve	1st Class A.R.	178
	Special Reserve	400
Local Companies abroad		230
Civilians		167
R.E. employed in India	Officers	10
	S. Staff	15
	Other ranks	94
	Total ...	5,890

CHAPTER V.

Historical.—Some Controversies and an Appreciation.

A successful service, such as the Submarine Mining proved to be, could hardly be established without some opposition and depreciation, and it is therefore not surprising to find that proposals were made from time to time, even by those in high authority, which would have resulted in very considerable changes both in details and organization.

These controversies have not only an important bearing on the dramatic ending of the service, but are in themselves very instructive as indicating the trend of military opinion in defence matters, and throwing light on many orders and arrangements which would be otherwise hardly intelligible.

Broadly speaking, there were two other organized bodies which competed with the Engineers for the honour of taking charge of the mines—these were the Navy and the Garrison Artillery. But the arguments for the change were not the same in both cases.

The naval argument was mainly based on the fact that a certain amount of nautical knowledge was necessary to lay out an efficient minefield. The Artillery argument was mainly that very close co-operation was needed between the mines and guns, and that therefore every gunner ought to know a good deal about mines.

These two arguments are however mutually destructive, as co-operation would be hindered rather than helped by removing the mines from military to naval control, while the nautical work would probably suffer if taught as an extra to a full course of Garrison Artillery duties.

As will be seen from the preceding chapters, the charge of the submarine mining defence fell to the Royal Engineers as the natural heirs of the pioneer work done by Sir Charles Pasley about 1839, and as a natural development in another element of the form of warfare, which gave them their name of Sappers and Miners.

There was at the time no doubt as to the practicability of this arrangement, but as the service began to grow and definite companies of Engineers were allotted for mining work, attacks began from both sides.

1873. The question was opened in 1873 in a memorandum by Brigadier-General Sir John Adye, Director of Artillery at Headquarters, addressed to the Surveyor-General. In this he points out that the officers and men of the Royal Artillery are entirely excluded from all participation as regards torpedo instruction and defence, that the protection of our harbours must be carried out by a close association of our naval forces, our land batteries and torpedoes, and that to ensure unity of purpose and completeness of design, the Artillery ought to be included in all combined arrangements, and should be instructed accordingly.

He recommended that a standing Committee, consisting of the Inspector-General of Fortifications, the Director of Naval Ordnance, and the Director of Artillery, should be established for the purpose of regulating the general principles of torpedo defence at home and abroad, that a proportion of Artillery officers and N.C.O.'s of the Garrison Brigades should go through a course of submarine mining, and that annual torpedo practice be carried out at each principal station at home and abroad by the Royal Engineers, Royal Navy, and Royal Artillery combined. He went on to suggest various experiments to get information on a subject which was still in its infancy.

Sir Frederick Chapman, the Inspector-General of Fortifications, in reply, forwarded a memorandum by Colonel Jervois, with the remark that he could not concur in General Adye's suggestions, and thought that the latter would not have put them forward had he possessed a more practical acquaintance with submarine mines and the present state of the mine defences.

The memorandum of Colonel Jervois, dated 5th April, 1873, deserves a more extended notice.

He began by a summary of the progress of events from 1863 onwards, which are given in the preceding chapters, and then proceeded :—

* * * * *

"The art of submarine mining cannot, as stated by General Adye, be said to be in its infancy. No doubt improvements may from time to time be introduced in this, as in other branches of the art of war, but we have already developed a perfectly efficient system for practical working purposes. So far from submarine mining being in its infancy, it has already arrived at the period of manhood.

Action of Navy in Matters Relating to Torpedoes.

"As regards the action of the Navy in matters relating to torpedoes, they have, as stated by General Adye, a torpedo school on board a ship at Portsmouth, and a Committee of naval officers is being formed for the consideration of matters relating to the subject. Certain officers and men of the Navy are put through a course of instruction of a similar character to that given at the School of Military Engineering at Chatham, but much shorter and more elementary. The Navy direct their chief attention to the naval or locomotive portion of the subject.

"It is essential, for a clear understanding of the question as regards the part which the several branches of the service should play in submarine warfare, to explain that there are two distinct classes of engines to be employed. One is the defensive submarine mine, which is sometimes mechanically self-acting, sometimes electro self-acting, sometimes fired by electricity from the shore. The other description is offensive, and is either fired from a vessel, as in the case of the Whitehead torpedo, or towed by a vessel, as in the case of the Harvey torpedo. The submarine mine is always stationary, and is worked by the Engineers from the shore. The offensive torpedo, on the other hand, being worked from 'on board' ship, necessarily becomes a naval weapon. In addition however to the knowledge of the mode of working naval torpedoes, it is essential for the Navy to have some acquaintance with stationary submarine mines, because naval attacks upon harbours will in future involve operations for the destruction or removal of submarine mines. Thus it is apparent why the Navy should have a torpedo school, and also why they should be acquainted with the nature of submarine mining operations. No such reason however can be alleged for the instruction of the Artillery in matters relating to submarine warfare.

Torpedo Defences Not Part of the Duty of the Artillery.

"The part that the Artilleryman has to perform in the defence of channels is to work and fire the guns of a battery; and, as regards submarine mining, the only knowledge required by the Artilleryman is that the officer directing the battery should be made acquainted with the *positions* of the submarine mines. This information will enable him to know in what direction, and on what points, he will have to lay his guns.

"The general direction of the defence would not be under the Artillery officer of the battery, but under the General or other officer commanding the whole force charged with the defences of a position. The firing stations of the submarine mines would, as a rule, be at some distance from the battery, and the Artillery officer would have his attention diverted from his immediate duty if he were charged with any function connected with submarine mines. He could not work his guns and look after submarine mines at the same time. If a portion of the Artillery were withdrawn from their own duties for the purpose of working submarine mines, they would obviously not be available for manning their guns; and considering how frequently it is stated that we have not nearly enough Royal Artillery to man the guns of our fortifications, it cannot be held with reason, even irrespective of other considerations, that this would be a wise or a prudent course. If it be urged that the Artillery should be augmented, in order that a proportion of them may be charged with submarine mining duties, it is obvious to remark that were an augmentation of force required for such a purpose it would be better applied to that branch of the military service which is already charged with the conduct of these duties. It will only be necessary to continue the systematic instruction of the officers and men of the Engineers which has been carried on for the last two years, and extend it to the numbers required, in order to provide a sufficient force of trained submarine miners to meet all the requirements of the Service.

Observations Respecting the Duties of the Various Arms of the Service in the Several Branches of Defence.

"General Adye observes in his Minute: 'It will, I think, be generally conceded that the protection of our harbours must for the future be carried out by a close association of our naval forces, our land batteries, and torpedoes; that the one will not be complete without the other, and therefore that, to ensure unity of purpose and completeness of design, the Artillery ought to be included in all combined arrangements, and should be instructed accordingly.'

"This paragraph involves the proposition that the officers and men of each branch of the Service should not only have a general knowledge, but also a special training in the duties of all the other branches; for although General Adye is only speaking of the defence of harbours, the same principle is equally applicable to the action of troops in the field or to the defence of land fortresses. But the defence of fortresses, whether by land or sea, must be conducted, as are all great military and civil undertakings, on the system of division of labour, under the direction of one head. The responsibility for the defence of a fortress rests with the Governor or other officer in command, and under his orders other officers would have local command of special districts. In each section of the defences would be certain officers who, by a well-defined division of labour, would each be charged with certain portions of the defence. On the land fronts the Infantry man the parapets, line the covered ways, occupy the musketry galleries, push out outposts, make sorties, and destroy the enemy's approaches. The Artillery man the guns, and are responsible for the efficiency of the armament of the works, and for the supplies of ammunition and other stores necessary for the guns. The Engineers protect the guns by blindages, prepare communications, run out counter-approaches in advance of the work, load the various countermines forming portions of the permanent system, construct new ones on the exposed fronts, lay the firing cables, and prepare the electrical apparatus for explosions. All these operations are carried out 'in close connection,' all under the general direction of the Governor or other officer in general command; but the sphere of duties of each branch or arm of the service and of its chief or head is distinct.

"The case is precisely similar on the sea fronts of a fortress, or in the defence of harbours and channels. Sorties are made by the Navy, either with armour-plated rams, powerful turret ships, or small speedy vessels, built and equipped as torpedo ships. The operations at Charlestown are a good example of the method of sorties. The Artillery man the coast batteries. The Engineers attend to works which may be required during the attack, and prepare and work the submarine mines. It will be observed that here the sphere of operation of each arm of the Service in the defence is perfectly distinct. Although all work 'in close association,' the duties of each are well defined.

"General Adye complains that the Artillery are 'excluded from any participation in the defence by submarine mines'; he however does not complain that they take no share in the defence by subterranean mines. Yet there is as close an association between guns and mines when the guns fire over earth in which mines are buried as when the guns are fired over water in which the mines are submerged. There is a very close connection for defensive purposes between the infantry, cavalry, and artillery of a force holding a position. 'One of them will not be complete without the other,' and although 'unity of purpose and completeness of design' are as requisite there as in the defence of a harbour, yet that unity of purpose and completeness of design are not to be found by taking the gunners from their legitimate work and making them perform the duties of cavalry or of infantry.

"It is to be found only by causing all of these branches of the Service to act each in its proper sphere, under one directing General, as it should be found in a fortress in the direction of the Governor or Commanding Officer.

Undivided Responsibility for Torpedo Defences Essential.

"It is essential that one head of each branch of the Service should be responsible, primarily to the Commanding Officer, ultimately to the State, for the proper conduct of the duties of his branch. General Adye omits to state who is to be responsible for the proper application of the formidable defensive power of submarine mines. Under the arrangement indicated by General Adye, who will be responsible? Is it to be the Officer Commanding the Artillery, or the Commanding Royal Engineer, or the Naval Officer, or all three? If General Adye contemplates that the Commanding Royal Engineer should be responsible while he is to be dependent upon such casual assistance as he can obtain from the Navy or the Artillery for the execution of the work, I would observe that this assistance would almost surely be withdrawn at the time when it would be most required, and the Commanding Royal Engineer would be left with only a fraction of the force necessary for completing or working his submarine mining arrangements. Neither the duties of artillery, nor those of infantry or cavalry, or any other portion of the service, could be carried on under such conditions, and yet General Adye deliberately proposes such an arrangement for a service in which it is of the utmost importance that the men and operators employed should be accustomed to act together, in which success is dependent on the correct manipulation of delicate apparatus, and for which a special training and knowledge are required more than for any other branch.

"That submarine mining operations can be carried on by two or more branches of the Land Service, with the occasional assistance of the Navy, is simply impossible; and I am sure a very slight experience of such work as has been carried on at the Nore and the Medway for more than two years past would convince General Adye of this fact.

Observations on the Proposals of the Director of Artillery.

"I have made these observations in reply chiefly to the general remark with which the Director of Artillery prefaces his three definite propositions. I propose now to deal with these propositions.

"It will only be on occasions when some special point has to be determined, such as those relating to electrical apparatus, or the intervals to be maintained between mines of different sizes with reference to their action upon ships or on each other, that any committee will be required for details relating to submarine mining; and all considerations relating to such details refer entirely to the province of the electrician, the naval officer, or the engineer.

"As regards a committee for considering the general principles of defence, of which submarine mining forms a part, the Defence Committee, of which the three officers named by General Adye—the Inspector-General of Fortifications, the Director of Artillery, and the Director of Naval Ordnance—are members, already exists for the express purpose of considering and reporting to the Secretary of State upon such questions as they arise. The Defence Committee consists of representatives of all branches of the Service, and is organized expressly—to use General Adye's words—to 'ensure that unity of purpose and completeness of design' in the 'protection of our harbours, which must be carried out by a close association of our naval forces, our land batteries, and torpedoes.' General Adye however proposes to destroy this 'close association' by the appointment of a separate standing Committee to consider defence by torpedoes; whilst defence by fortifications and artillery would be considered by the Defence Committee. I submit that this plan, instead of producing 'unity of design,' would only lead to division of purpose, complication, and confusion.

"General Adye's second proposition is:—

"'That a proportion of artillery officers and non-commissioned officers of the garrison brigades shall go through a course at Chatham, and then be distributed to the various stations.'

"This is simply a proposition that a portion of the Royal Artillery should be employed to take the place of an equal portion of the Royal Engineers.

"I have already shown in an earlier part of this Minute that this would be very disadvantageous to the public service. No reason exists for putting artillerymen through a course of submarine mining instruction at Chatham. On the other hand, there is good reason why they should not be put through such a course.

"Two classes of labour are required to place a system of submarine mines in position—skilled and unskilled. When placed in position, skilled labour only is required. The skilled labour would be supplied sufficiently from the men of the Royal Engineers trained at Chatham, while for the unskilled, involving simple manual labour, no training whatever is necessary.* The trained men would not only be required to place the mines in position, but afterwards, and especially during an attack, to keep the service efficient. Under these circumstances artillerymen would not be available, because at the very time when their services as skilled submarine miners would be most urgently required, they must

* This opinion of Colonel Jervois was hardly borne out by later experience, but this did not affect his argument.

necessarily be employed in manning their guns. It would consequently be simple waste of time and money to train them as submarine miners when they could not be employed as such, even on emergency. They might be employed, and so might any other troops, in performing certain duties involving simple manual labour if available at the period when the mines were being placed in position, but this would necessitate no previous training.

"It is not however maintained that artillery officers should be excluded from a knowledge of the principles and practice of submarine mining. It is no doubt desirable that officers of the Royal Artillery should possess a general knowledge of this branch of defensive warfare precisely on the same principle that, at the Royal Military Academy, they learn something of subterranean mining, and as, at the same place, officers of the Royal Engineers learn not only the theory, but something of the practice of gunnery.

"General Adye's third proposition is :—

"'I strongly recommend that annual torpedo practice be carried out at each principal station at home and abroad by the Royal Engineers, Royal Navy, and the Royal Artillery combined.'

"It is no doubt essential that the officers and men charged with the defence of our ports by submarine mines should be thoroughly trained and practised periodically. Such practice was carried on in the Medway last autumn by the trained submarine miners of the Royal Engineers, and it is intended that it shall be extended, as far as practicable, to all stations, when the officers, men, and stores shall have been distributed.

"As regards the carrying out of this practice by the Royal Engineers, Royal Navy, and the Royal Artillery combined, I have already shown in this Minute that the true combination is for each arm of the service to be charged with its own duty under one directing head, and that it is better to leave to the Engineers the entire charge and responsibility of the submarine mining branch of the defence. I should deprecate the employment of gunners to work the submarine mines, even were such an arrangement practicable, precisely as I should consider it unwise to apply a portion of the Engineers to the working of the guns of a battery.

"With regard to the observation in the latter part of General Adye's Minute, he does not appear to be aware that the laying down of torpedoes and cables at various depths in different parts of a channel, the testing of the electric batteries, etc., have for a long period formed part of the ordinary practice of the Royal Engineers. The Admiralty have also already co-operated by lending the necessary steamers, boats, and barges for the purpose. The information General Adye proposes to acquire has already been obtained. As I have before stated, the subject of submarine mining is not in its infancy, but has arrived at manhood.

"Finally, I submit that, should war arise, the arrangements proposed by the Director of Artillery would inevitably create the confusion which he desires to avoid."

WM. F. DRUMMOND JERVOIS.

5th April, 1873.

It is difficult, when reading Colonel Jervois' masterly Minute, to realize that it was written 35 years ago. It shows such a thorough grasp of the general principles of defence organization, and of the relative duties of Navy, Artillery, and Engineers, that it might well have been delivered as a lecture to the Staff College at the beginning of the 20th century.

Even as it was, it was always referred to by subsequent committees as a standard of perfection, to which any new proposals could be referred.

About the same time as General Adye was making his attack, Capt. Fisher, R.N., then in command of the *Vernon*, which had just been established as the Naval Torpedo School, got out proposals for taking the whole of the submarine defence into naval hands. But these proposals were not supported by the Board of Admiralty, on the ground that the mobility of the Navy would be impaired if they were employed on any part of the fixed defences, a statement of general policy which governed all the actions of the Admiralty in defence matters for many subsequent years.

At a meeting at the Admiralty on 2nd July, at which there attended Sir A. Milne, R.N., Capt. Hood, R.N., Sir F. Chapman, I.G.F., Brigadier-General Adye, D. of A., and Colonel Jervois, it was decided :—

(1). That all necessary steamers, boats, barges, and tackle, with the requisite number of seamen for torpedo defence, should be provided by the naval authorities, and be placed at the disposal of the military authorities for the purposes required.

(2). That information as to the position of torpedoes be communicated to the Officer Commanding the Royal Engineers, the Officer Commanding Royal Artillery, and the Naval Commander-in-Chief at each port.

Except that the employment of the naval *personnel* proved unsatisfactory, as explained in Chapter II., so that they were replaced by Militia, the above arrangements remained unchallenged till 1886.

In this year the whole organization of the Royal Engineers was **1886.**
under consideration by a Committee presided over first by the Hon. Guy Dawnay and then by Lord Sandhurst. A member of this Committee, Major-General C. G. Arbuthnot, R.A., again raised the Artillery view that the R.A. should take over the mine defences.

This was replied to by Sir John Stokes (D.A.G., R.E.) and Sir Andrew Clarke (I.G.F.). Both referred to the memorandum of Sir W. Jervois, already quoted, as having settled the question for 12 years. Sir John Stokes also calls attention to the fact that the large growth, not only of the regular but of the auxiliary Corps of

Submarine Miners, made the transfer of their duties to another corps very difficult to carry out in practice. It was not likely that officers and men would consent to be transferred, so that the change would make great and serious confusion, and should not be attempted unless very strong reasons could be urged in support.

Sir Andrew Clarke followed much on the same lines, and concluded his remarks as follows :—

"Having now dealt with the memorandum ot Sir C. Arbuthnot, I desire to point out that this is not the first time the suggestion has been made by the Artillery that the submarine mining defence should be transferred to their charge. Some 12 years ago the question was raised by Sir John Adye, who, apparently in ignorance of the great progress that had been made in the development of submarine mining, approached the subject as if this mode of defence were still in its infancy, and would be little effected if such transfer were made. But a memorandum of Sir William Jervois, which has been laid before the Committee, showed very conclusively that very great attention had been paid for some time to the science of submarine mining, and that under the care of the Royal Engineers very considerable advances had been made and a complete system worked out, and that there was no reason to suppose that defence by submarine mines would be so well carried out by the Artillery as by the Engineers, to whom, as intimately connected with one of these special studies—military mining—it more properly belonged. In the 12 years which have elapsed since the able memorandum of Sir W. Jervois was written, the arguments which were then held adequate have become weightier year by year.

"If however it be considered desirable to re-open a question of such importance as the charge of submarine mining defence, which was so carefully considered in its earlier stages, and the duties of which have been performed and the development fostered for the last 17 years by the Corps of Royal Engineers, the first step is to compare the organizations obtaining in other countries and the result of the experiences gained by these countries in the same period. And what do we find? That, among the great Powers, America and Russia have entrusted submarine mine defence to their Engineers, while France, Germany, Austria, and Italy have committed it to their navies. Of the lesser Powers, Spain, Sweden, and Denmark have placed this defence in the hands of their navies, and in no country has it been considered an artillery duty. * * *

"In this country it has hitherto been considered that submarine mining should be entrusted either to the Navy or to the Royal Engineers. There are many and excellent reasons why it should be in the charge of the Navy, but the particular circumstances of our country require that the Navy should be kept up to the greatest possible strength, and made as mobile as possible for offensive purposes, and if it were given the duty of the submarine mining defences of the military ports, commercial harbours, and coaling stations of the Empire, it would detract from its offensive efficiency, would burden it with duties that might seriously impair its mobility, and would raise an element of confusion in the responsibility attaching to the defence of ports. All this has not only been acknowledged but urged by the Admiralty, who have only recently decided that the guard boats for submarine mining defence should be under military control, and should not be borne in Navy Estimates. * * *

"By careful selection of the officers, by painstaking instruction of both officers and men, and by continual study of the progress of electrical science in civil life, as well as of the advances made in developing the counter-attack by the Navy, a *personnel* and system have been built up during the last 17 years which is inferior, I venture to believe, to none in the world, and in one respect is superior to most, viz., the carefulness and skill in manipulation by which the country has enjoyed immunity from those fatal accidents of which we have heard from time to time in foreign countries, and from which our own Navy has not been exempt.

"We have now in the Royal Engineers selected officers and men whose continuous attention has been for many years devoted to the development of submarine mining, and whose experience is as great as any in the world. Indeed, we still retain in the Service officers and non-commissioned officers and men who carried out the experiments for the original committee referred to by Sir W. Jervois. The prominence that submarine mining has attained in this country, under the sagacious encouragement of His Royal Highness the Field Marshal Commanding-in-Chief, is no doubt due to the lead taken at the outset, when other nations appear to have hardly realized the important *rôle* which this species of defence was destined to play in the future, and also to the energy and zeal displayed by those on whom the work devolved in developing a crude art into an accurate science.

"My predecessor, Sir Lintorn Simmons, took a lively interest in submarine mining, and much is due to him; and I have had the good fortune, with the active assistance of the present Deputy Adjutant-General, Royal Engineers, Sir John Stokes, to have been able to double the *personnel* for submarine mining defence, although it is still short of what is required, and to organize a system for defence of mercantile ports capable of large development. * * *

"This is a movement requiring considerable intelligence and care in its supervision, for it is necessary, on the one hand, to ensure efficiency in a work beset with great inherent difficulties, and, on the other hand, to adapt the arrangements to some extent to the capabilities of the Volunteers, while at the same time a minimum of modification in the system approved for the military ports must be maintained.

"The dangers to those employed on the work are, as I have already said, only too clearly attested by records of loss of life in other countries and in our own Navy, and the difficulties of making a successful defence, although less evident to the uninitiated, are most strongly felt by those who have the most experience. It would therefore, in my opinion, be incurring a most serious responsibility to attempt to transfer the charge of this movement to an inexperienced directorate, and to break the continuity of what has been already done."

ANDREW CLARKE, *I.G.F.*

The proposed change was supported by Lord Wolseley, who advocated the formation of a Coast Defence Corps, and by Major-General H. A. Smyth, R.A. It was opposed by Sir A. Allison, who considered that a separate organization for the submarine mining work was essential, whether it was part of the R.A., R.E., or a special Coast Defence Corps.

In their final report in June, 1886, the Committee say that it is not expedient at present to make any separation of one part of the Corps of Royal Engineers from another, but recommend that, as far as possible, the officers and men should be retained in the branch for which they are selected and specially trained.

The operations at Milford Haven in the summer of the same year again caused the organization of the Coast Defences to come under review, and in October, 1886, Lord Wolseley addressed a Minute to the Secretary of State (Mr. W. H. Smith), in which he strongly advocated that the Garrison Artillery should be separated from the Horse and Field Artillery, and should take over the electric light and submarine mining duties. One reason urged was that it would be necessary to find congenial employment for the Garrison Artillery, and that the charge of the submarine mines and lights would justify their being placed in the same position as regards pay, etc., as the Royal Engineers. He recommended a committee to consider this question.

The Secretary of State concurred in these proposals, and a committee was appointed in December, 1886, composed of

Lieut.-General Sir A. Allison, Commanding Troops at Aldershot, President.
Lieut.-General L. Nicholson, Inspector-General of Fortifications.
Major-General Goodenough, Inspector-General of Artillery.
Major-General Hon. R. Monck, Commanding at Chatham.
Major-General Lyons, Commanding at Devonport.

A minute by the Inspector-General of Fortifications was laid before the Committee.

In this, after referring to his personal experience at Milford Haven, he points out the increasing necessity for improving the general organization of the defences, the training of the Royal Artillery with heavy guns, and the extension of the Submarine Mining Service to include guard boats. In his opinion the principal defect in the present system was the absence of any organized staff to ensure the co-operation of all the various services, guns, mines, and lights, in a fortress, and he outlined an organization under which each fortress would be a separate command with separate and distinct organizations for the various groups of duties—guns, mines, and land defence—each group having their own technical head responsible to the Fortress Commander for their special duties, but all trained together as a whole under the Fortress Staff. Such an organization could be provided by a simple extension of existing arrangements, and need not involve any dislocation of existing corps.

The alternatives to improving the existing organization were the transfer of the whole responsibility for *personnel* and *matériel* of coast defence to the Navy, or to create a new military organization as a Coast Defence Corps. The advantages of a transfer to the Navy were to give unity of direction to the fixed and floating defences of the coast, but it would involve the development by the Admiralty of a special branch for passive defences, and there would always be the probability of the withdrawal of the naval garrisons in case of a strain on the naval *personnel*. The advantage of a special corps which would absorb the Garrison Artillery, Submarine Miners, and possibly Royal Marine Artillery, would be again the unity of control of all parts of the defence. The disadvantage was that while such a corps would require a very scientific training, its separation from the field army and consequent loss of active service would make it necessary to offer special inducements of pay, etc., to obtain officers and men of sufficiently good quality.

Major-General Hay, D.A.G., R.A., also submitted a memorandum on the subject.

He pointed out that both the Garrison Artillery work and the submarine mining required in many respects the same form of technical training, and after devoting some space to showing that the training of the Artillery was defective, and the officers not properly informed of the details of defences, he concluded by a summary of the advantages and disadvantages of transferring the whole defences to (*a*), the Royal Navy; (*b*), the Royal Engineers; (*c*), the Royal Artillery.

In regard to the latter he pointed out that they already existed at all ports where there were mines, that their artillery work, once the drill and knowledge of details was acquired developed into a somewhat monotonous routine, which would be much relieved if they acquired the submarine mining duties. He concluded with an estimate of cost which showed a saving of £23,000 a year.

This memorandum was laid before the Committee, and in reply to it Sir L. Nicholson, the I.G.F., forwarded a criticism of the figures submitted. He pointed out that as no saving in the total *personnel* could be effected by combining the two services in one corps, and as all the Artillery were to get Engineer pay, there would necessarily be an *increase* of expense, which he estimated at £72,000.

Col. R. Grant, the D.A.G., R.E., followed on the same lines. He pointed out that the memorandum tried to prove two propositions:—

(1). That coast defence, to be as efficient as possible, should be the duty of one special corps.

(2). That this special corps, both on grounds of economy and efficiency, should be the Royal Artillery.

That there were, as a matter of fact, four distinct bodies interested in coast defence, viz., Artillery, Engineers, Infantry, and the Navy, and that no practicable scheme had yet been put forward to combine all these into one corps. Also it was somewhat illogical to argue that because the Artillery officers and men were insufficiently instructed and not interested in their work they should add to this the complicated and technical work of submarine mining, which at present occupied the whole time of a considerable number of Engineer officers and men.

On the general question the Inspector-General of Fortifications added yet a third Minute, pointing out that the organization of the defence at Milford Haven had been admittedly defective, and in spite of this the Defence had been successful in resisting the Attack. The first step was therefore to improve the organization, and when this had been done it would be time enough to consider whether any radical change was necessary in the division of duties between the various corps.

In the result the Committee reported in January, 1887 :—

(1). That Submarine Mining is a subject so intricate and scientific in itself as to require special instruction in officers, N.C.O.'s and men, such as can best be given in a branch of the Service with distinct technical training.

(2). That Garrison Artillery is a subject so intricate and scientific in itself as to require in officers, N.C.O.'s, and men a special and distinct technical training.

(3). That submarine mining defence should remain with the Royal Engineers rather than be transferred to the Royal Artillery.

They added, in explanation of their rejection of General Hay's proposals, that it would be impracticable to provide one body of men who would be equally fit to undertake at any moment the duties of Garrision Artillery or Submarine Mining.

These conclusions were accepted.

1890. But though settled for a time, there were still a good many advocates for the Coast Defence Corps, among whom was Mr. E. Stanhope, who became Secretary of State for War in 1887. The experiments with electric light in 1889, which led to recommendations for a considerable increase in the number of lights used with the gun defence, had started the further question whether such lights should be entrusted to the Royal Artillery or Royal Engineers.

In May, 1890, Mr. Stanhope assembled a Consultative Committee, of which he was himself the President. The members were H.R.H. the Duke of Cambridge, Earl Brownlow, Lord Sandhurst, Lieut.-General Sir W. Jervois, Major-General E. F. Chapman, Major-General Goldsworthy, M.P., and G. C. T. Bartley, Esq., M.P.; Major R. M. Ruck, R.E., and Capt. W. St. P. Bunbury, R.A., were the Secretaries.

The terms of reference were very large and included the whole system of coast defence and the organization of the Royal Artillery and Royal Engineers, including Auxiliary Forces. The separation of the Royal Artillery into field and fortress branches was assumed.

In their final report they discuss four proposals :—

(1). The formation of a separate Coast Defence Corps. This they reject somewhat reluctantly on the ground that it will involve serious interference with existing corps.

(2). The formation of a Staff Corps of Officers for Coast Defence, leaving the men in separate corps. This was also rejected as being open to all the objections to (1) and being a less effective remedy.

(3). The transfer of all fortress duties, including artillery, to the Royal Engineers.

This is declared to be feasible, but likely to make the Royal Engineers unwieldy.

(4). The transfer of all such duties to the Garrison Artillery.

The Committee favour this view, provided the Garrison Artillery is properly organized and that due care is taken to safeguard the interests of existing corps.

On the question of the duties to be entrusted to the reorganized Artillery the Committee was divided. Four members—Rt. Hon. E. Stanhope, Major-General Chapman, Major-General Goldsworthy, G. C. T. Bartley, Esq.—were of opinion " that economy and unity of action will be promoted by gradually transferring to the Garrison Artillery the charge of all electric lights."

The other four members—H.R.H. the Duke of Cambridge, Earl Brownlow, Lord Sandhurst, and Sir W. Jervois—considered that " electric lighting has hitherto been the duty of the Royal Engineers, and the Committee see no sufficient reason from the evidence why they should be relieved of this duty."

In a minority report the last four members pointed out that the production of the light by the Royal Engineers was a highly technical service, and there was no reason why the fact that the Royal Engineers produced the light should prevent the Royal Artillery controlling its use, just as in the Navy the engine-room staff produced the light and the gunners directed it.

On the question of submarine mining the majority of the Committee reported that they thought it should form part of the duties of the Garrison Artillery, but as the transfer would involve considerable interference with existing corps and would take some years to effect, they forebore to make any recommendation on the subject.

Three members—H.R.H. the Duke of Cambridge, Lord Sandhurst, and Sir W. Jervois—signed a minority report protesting against the paragraph as useless, as no action was recommended. Also the proposal was against the decision of several previous committees and against the weight of the evidence of the witnesses examined by the present committee.

They conclude in a terse sentence which really sums up the labours of this and the previous committees :—

"It is submitted that the true solution of the problem before the Committee is to be found in a well-organized system of command, in the necessary improvements of existing departments, and not in disturbing the most efficient parts of our present organization."

In appendices to the Report, the following officers supported the view of the minority :—

Colonel H. Geary, R.A.
Major-General Alderson, Director of Artillery.
Lieut.-General Sir L. Nicholson, Inspector-General of Fortifications.
Major-General R. Grant, D.A.G., R.E.
Major-General Markham, D.A.G., R.A.

This was practically the end of the Artillery attack on the Submarine Mining Service, and when shortly after this the Garrison Artillery was separated from the remainder, it successfully falsified the gloomy prognostications of Major-General Hay and other critics, and developed into the fine service as it exists at the present day

1889. In 1889 an attack was made on the Submarine Mining Service from a new and unexpected direction in an article in the proceedings of the Royal Artillery Institution by Major G. S. Clarke, R.E.

Major Clarke was even then known to a wide circle as one of the leading advocates of what may be termed the modern system of fortification, and therefore his opinion on the question of submarine mine defence carried considerable weight.

His article, which was termed "Submarine Mines in Relation to War," was not, as might be supposed from the method of its publication, a reasoned account of the position of mines in our defences, but a highly critical attack on that position.

Read from the point of view of a critic who is purposely making the best (or the worst) of his case, in order to provoke discussion, the paper is a very valuable one and contains much food for thought.

But in order to criticize at all it is necessary to have something to attack, and as Major Clarke was unable or unwilling to quote the actual existing regulations, he had to fall back on such publications as were accessible to the general public. These were "Notes on Submarine Mining," by Colonel Stotherd, published in 1871, and "Submarine Mines and Torpedoes," by Lieut.-Colonel Bucknill, which appeared in *Engineering* in 1888, and was published in book form in 1889.

In the first of these Colonel Stotherd was writing as an advocate for what was at that time an almost unrecognized form of defence, everything was naturally *couleur de rose,* and he claimed for mines possible fields of employment which never entered into the calculations of the British War Office.

Colonel Bucknill, on the other hand, was writing, to some extent, as a critic, and with great loyalty was very careful not to describe the actual operations and methods adopted in the British Army. His suggestions for the use of mines were thus all based on the defences which might be adopted by certain countries other than England.

In criticizing details based on these publications, Major Clarke was really only advocating principles, many of which were then and afterwards accepted by the War Office.

The paper opens with a statement of the position of mines which deserves quotation :—

"If it (the mine) has any value at all, its presence or absence must affect the general scheme of which it forms part. That scheme, unless considered as a whole, will necessarily be inharmonious, extravagant, or unsatisfactory."

It then gives a very valuable criticism of the use of mines in war, and shows that the experience of the American War and others give very little guidance as to what should be the policy regulating the use of mines in British ports.

Of his more detailed criticism of mining details, much was based on an inadequate knowledge of the subject ; in other cases the criticism has been met by improvements in methods and material, such as the more rapid laying of mines or training of observers. But on the whole Major G. S. Clarke admitted that a restricted use of mines would be useful, though he appeared to think that their application had been excessive.

A good deal of criticism was also devoted to the necessity of free ingress and egress of shipping and the importance of the mine defence offering no hindrance to the traffic. This was, of course, a matter of traffic regulation in war, which was certainly not efficient at the time, but was also not the duty of the Submarine Miners, and was really very little affected by the existence or otherwise of a mine defence.

A statement was made that if the weather was too thick to prevent effective use of guns, most ports are safe from attempted entry. But actual observation made at all ports a year or two later showed that at every place vessels habitually entered ports at times when they could not be seen from the shore, even when there was no pressing necessity for them to do so.*

One other point may be noted, and that was the claim that a gun

* This was fully borne out by the experiences of the Russo-Japanese War.

defence of inner waters at such places as Harwich and Mauritius would in itself be a sufficient deterrent to all naval attack.

Assuming the object of the enemy is to effect some definite damage to shipping or docks, the most that an inner gun defence would ensure would be the destruction of the enemy after he had effected at least some part of his object, while the operation of sinking him by gunfire in the middle of a crowded harbour would be attended by at least some risk to our own shipping. A mine defence, on the other hand, would stop the enemy before he had reached the inner waters.

This point is of some importance, as the defence of inner waters was a cardinal feature of the system of defence adopted by the School, of which Major G. S. Clarke was a prominent member, and much money was expended on this form of defence which might have been saved or better employed in strengthening the minefields.

But the above are details. The main point running through the paper was a claim that the whole question was one for naval decision, the scale of attack was a naval question, the control of traffic was a naval question, the position of mines and their placing in position was a naval question ; in short, the claim of what was afterwards termed the "blue-water school" was stated clearly and forcibly.

And with this claim the Submarine Miners had no quarrel. At every stage of the evolution of submarine mines naval opinion had been consulted, naval officers were members of all committees, even of those which dealt with the actual details of the mine apparatus, and naval advice was always obtained on all defence questions.

It is true that at this time the Admiralty were not very interested in such questions, but it is also true that our standard of naval strength was very low and the value of the command of the sea very little appreciated.

When the blue-water school succeeded in rousing the interest of the Government and the nation to the necessity of increasing the standard of naval strength, many military officers, including the leading Submarine Miners, were among its strongest supporters, and it is one of the weak points of this agitation that its extreme supporters thought it necessary to attack military policy under the mistaken impression that an increase of naval expenditure could only be obtained by a reduction in the Army Estimates.

This article is now in some sense ancient history, but it is still of interest, not only on account of the distinguished position attained by the writer, but because it was, if not the beginning, one of the indications of one of those waves of opinion which occasionally produce unexpected results in the Government of this country.

There was at this time a considerable revival of interest in the state of the Navy, a big naval loan was being spent in rapidly pushing on new ships, and it is not surprising that any scheme which promised increased efficiency to the Navy found ready hearers. Thus the agitation to transfer coast defences to the Marines received considerable support both in and out of Parliament.

The small experiment of employing Marines in the defences at Esquimault was hailed as the beginning of a change which would end in the transfer of all coast defences to the Admiralty, and many experienced officers, including Sir W. Drummond Jervois himself, supported this view. But another body, headed by Sir J. Colomb, saw quite clearly that such a large transfer would necessitate the formation of a special force under the Admiralty, and that it would be impracticable to give the whole of such a force a Marine training. They therefore limited their proposals to the occupation of certain colonies abroad only, and these were to be garrisoned by a very small number of Marines, who were also to act in some undefined way as a reserve for the fleet.

In all these controversies the mines played only a subordinate part, except that the fact that a certain amount of nautical knowledge was required to lay them out was always brought forward as an argument for naval control of the whole defences.

Meanwhile, possibly stimulated by these controversies, the real solution of the whole question, viz., the careful organization of each fortress advocated so strenuously by Sir A. Clarke, Sir L. Nicholson and Sir R. Grant, and their submarine mining advisers, made steady progress; the Joint Naval and Military Committee dealt with principles, while the details of the Colonial defences were ably dealt with by the Colonial Defence Committee, of which Major G. S. Clarke was secretary. It was becoming evident that the Navy must take their share of the work, especially in providing and manning the outlying force of torpedo boats and in the regulation of traffic. The Admiralty, while disclaiming all responsibility, were helping on these points, frequently criticizing the arrangements and sometimes pressing on the War Office the advisability of increasing guns or defences. They were especially nervous about torpedo-boat attack, and this led them to introduce booms on their own initiative. In this case they departed from their previous principles and undertook the responsibility of constructing and maintaining them, though for several years they had no adequate organization for this purpose. It seems unfortunate that the trend of public opinion prevented this addition being discussed. After all, a boom is, like a minefield, a special form of obstruction, and as such should be treated as an adjunct to the gun defence. If booms are constructed without reference to other forms of defence they are likely to be unduly heavy and expensive, and may be badly placed. Also, had the booms been a military charge, there was ready to hand, in the Submarine Mining Militia, a body of men specially competent by knowledge and training to make this part of the defence fully efficient.

1903. In 1903 two little clouds appeared on the horizon, which were gradually to spread until, with startling rapidity, they were to absorb the whole of the 40 years of submarine mining work of the British Army.

The first of these came with the development of the submarine boat, which had been under trial for some little time in the Navy. It had not by then really proved its usefulness, but great things were expected of it. One thing had however become apparent, and that was that, compared with other forms of torpedo craft, the submarine was especially dependent on sheltered accommodation being readily available, where the crews could get rest and where stocks of fuel could be stored. For these purposes it occurred to some naval officers that the Submarine Mining Establishments, with their piers, workshops, and adjacent barracks, would be very suitable for the purpose.

A suggestion was then made by the Admiralty that they were prepared to definitely allot submarine boats to the principal naval ports, and that therefore mines could be withdrawn. This proposal was submitted to a joint Naval and Military Conference, but this failed to reach an agreement as regards the one essential point.

The Chairman of the Conference was Lieut.-General Sir W. Nicholson, the Director of Military Intelligence. The representatives of the Admiralty were Capt. W. L. Grant, Capt. H. L. Heath, Commander H. W. Richmond; and of the War Office, Colonel R. M. Ruck, R.E., Colonel N. M. Lake, R.E., and Lieut.-Colonel G. H. Bittleston, R.A., with Major H. N. Dumbleton as secretary. They were asked to consider "the future functions of submarine mines in war."

Their report was completed in December, 1903, and an interesting table was added, which gives the relative cost of various portions of a defence.

A battery of two 9·2" guns complete was estimated to cost £63,700 and to require 2 officers and 49 men. A battery of two 6" guns cost £24,500 and required 2 officers and 40 men.

A minefield for a channel 2,000 yards wide, including all buildings, pier, etc., cost £45,000, and for a channel 1,000 yards wide £30,000; the former would require 4 officers and 50 men for maintenance, with 2 officers and 100 men in addition (who could be auxiliaries) while laying out; the latter would require 3 officers and 35 men, with 1 officer and 65 auxiliaries. In each case the auxiliaries could afterwards help with the lights.

A submarine boat was stated to cost £40,000, with a crew of 1 officer and 4 men.

A Brennan torpedo installation cost £21,500, and required 1 officer and 10 men.

In comparing these figures it must be noted that the minefield estimated for, as well as the Brennan, was a complete defence, while few gun defences consist of only one battery and a single submarine boat would not form a very effective flotilla.

In their report the Committee point out that provided there is sufficient inducement to the enemy to run past the defences, the attack can be met in one of four ways.

(*a*). By using guns only which involves increasing the artillery defence to a considerable extent.

(*b*). By supplementing the artillery defence by a minefield.

(*c*). By employing torpedo craft to assist in the defences.

(*d*). By supplementing the artillery defence by one or more Brennan installations.

The conditions under which any of these methods should be adopted were discussed, and with regard to submarine boats, the naval side of the question was summed up in the following paragraph of the report :—

"In the opinion of the naval members of the Conference, the presence of these vessels, with even their present capabilities, will afford an equally efficient defence, and have a more deterrent effect against sustained attack or bombardment than would a submarine minefield. They consider also that minefields will be inadmissible at ports at which these boats are allotted for defence, and in which they should be free to manœuvre at all times, except in such channels as would be permanently closed to traffic in war."

The military members dissented from the above paragraph.

The disappearance of the minefields prevented the further discussion of the above points, but experience in the use of submarines hardly bears out the above claim. The submarine boat is, reduced to essentials, a small torpedo boat with special facilities for concealment by day, but practically useless at night against a ship under weigh and with a very limited radius of action at any time. If sufficient torpedo and submarine boats are provided to ensure that they cannot be evaded by an enterprising enemy, their use will no doubt increase the range of the defences, and in this way will undoubtedly be a deterrent against sustained attack or bombardment, though both these forms of attack have for some years been ruled out by the Admiralty as inconsistent with our naval supremacy.

But such a change of the system of defence cannot be taken as exclusively affecting the mines; these latter are adjuncts of the artillery defence, designed to ensure that the enemy, before he can reach his objective, must engage and silence the artillery of the fixed defences. If the use of submarine boats makes any change possible in the fixed defences, it lies in the direction of replacing both guns and mines.

It thus foreshadows a definite change of policy in the substitution of a rather expensive naval form of mobile defence for the cheaper fixed defence of guns and auxiliary obstacles.

It is difficult to see how the addition of boats which operate in front of the area covered by gun fire can be a substitute for mines which act at the rear of this area, while the requirement that submarine boats should have free ingress and egress at all times strikes at the very basis of all fixed defences. No gun defence is of value unless either it can fire on all it sees or there is an efficient organization for the identification of traffic. If the latter exists, the presence of a minefield, with a friendly channel, offers not the least obstruction to friendly traffic, and there thus seems no reason why the addition of submarine boats should be in any way antagonistic to the mines.

The second cloud to which allusion has been made came in the form of a question in Parliament in 1903 put by Sir J. C. Colomb, K.C.M.G., that the total of the Army Estimates for 1903-4 might be subdivided into three general heads:—

Field Service (Home and General).
Fortress Services (Naval Ports, Commercial Ports, and Abroad).
Aquatic and Submarine Services.

The return which was presented a week later, after allotting about £14,000,000 each to the field and fortress items, gave a total of £556,000 as the cost of the third sub-head, or Aquatic and Submarine Services.

This return was extensively quoted in subsequent discussion as giving the annual cost of the Submarine Mining Service, but not only did the total of £556,000 include the cost of the electric-light defences, but it was unfortunately considerably overestimated.

The exact assessment of the numerous Army votes for transport, buildings, etc., to ascertain the cost of any particular service, is a matter of considerable difficulty and would require much more time than is usually allowed to answer a Parliamentary question. But a careful calculation made later showed that the actual cost of the Submarine Mining Service, omitting pensions and general War Office charges, was about £330,000, of which only £125,000 could be saved by the total abolition of all mine defences. Or put in another way, the calculation would read thus:—The cost of the whole submarine mining defence at all ports chargeable to Army Estimates was about £180,000 a year; the cost of the electric-light defence, if organized as a separate service, would have been about £200,000 a year. By organizing them, as had been done, into one service, a reduction was made on the total of about £50,000 a year. It is curious that the very efficiency and cheapness of the submarine mining organization should have been afterwards made a ground of complaint that so little could be saved by its abolition.

It may be added that these latter figures proved remarkably accurate in practical application.

Following the report of Sir W. Nicholson's Committee, considerable correspondence took place between the Admiralty and War Office, which resulted in a proposal to appoint a Joint Committee, of which Sir J. Wolfe Murray, Master-General of the Ordnance, was to be President, to consider the defences as a whole, including minefields, and report how far they would be affected by the development of submarine boats. **1904.**

But this Committee was cut short by the decision of the Committee of Imperial Defence already referred to.

These events are too recent to permit of discussion in a publication of this description.

Although, perhaps, it is too early to properly estimate the value of these defences to the Empire, it seems undesirable to end this chapter without some attempt to generalize on the whole question. Future generations will want to know the facts, but they will also search deeper for the underlying principles, the influence of submarine mines on the general question of defence, whether reasonable prescience was shown in adopting such a form of defence, and whether reasonable care was taken to adapt the scale of the minefields to that of the other defences of our ports.

The main line of criticism of our mine defences is really directed not against submarine mines alone, but against any and all systems of coast defence; it is summed up in the claim that a supreme Navy is essential to the maintenance of the British Empire, and that, granted a supreme Navy, no serious attack can be made on coast defences. But in practice the absolutely supreme Navy is unattainable, and it is possible only to maintain a certain supremacy over the the next one or two possible enemies. An attack of some sort on our coasts is therefore rendered possible, and it is only reasonable to provide some visible local means of defence. The question therefore becomes one of proportion, of what amount shall we spend on our ships and armies, what amount on our fixed defences.

The officers responsible for our defences naturally want to have a little bit in hand; the officers responsible for the Navy grudge every penny spent outside their own service. The question becomes then one for discussion and compromise, and in the give and take of the English Services it has always been found possible to reach a definite agreement.

One form of argument may be discounted. It is that in which the whole cost of fixed defences is added up over a term of years, showing an expenditure of some millions, and the question is then asked, how much better off might we not have been if we had spent this money in other ways?

But the financial question should be considered not as a total, but as a percentage of the whole naval and military expenditure, and by this standard we find that the expenditure on fixed defences during the last half-century was only about $2\frac{1}{2}$ per cent. of the total. It might have been possible, if our predecessors had been able to forecast the future, that this percentage might have been reduced to 2 or even $1\frac{1}{2}$. On the other hand, no one would have grumbled at the time if it had been increased to 5 per cent. or more. When submarine mining was first introduced, the theory of the command of the sea was little understood, and, if it had been, would have been difficult to apply in practice. Naval warfare was in those days much less definite and less decisive than it seems likely to be at the present day; the gun had not yet beaten the armour and the means of propulsion were still far from being independent of varying conditions of weather. The type of gun in our forts was far from reaching the modern standard, and was decidedly inferior to that on board ships. And the fact remains that the whole temper of the Government and the people was to rely less on the Navy and more on visible defences.

Under these circumstances the Engineer officers evolved in the submarine mine a system of defence which had great moral value and could be readily applied to modify and improve existing defences at comparatively small cost. There can be little doubt that its cost was more than repaid by the reductions of gun defence which it made possible, while the sense of security it gave probably had much to do in preventing scares and popular demands for additional defences.

Whatever may have been the shortcomings of the past generation, the fact remains that during the 30 years in which mines were included in our fixed defences, our combined naval and military arrangements were such that no hostile power has ventured even to challenge our supremacy on the sea.

And—paradox as it may seem—the efficiency of a Navy and Army should be judged not by the winning of victories, but by the absence of wars.

If then it may be assumed that the introduction of mines was justified by the tone and temper of the people and the general defence policy of the period, there can be little doubt that the work was thoroughly well done, with great care and forethought.

In every respect the mine defences were most economical; in first cost they compared very favourably with any other form of defence, the annual maintenance charges were very low, while a company of 3 officers and 60 men cannot be considered an extravagant addition to the garrison of one of our large fortresses.

The early designs of stores, too, proved remarkably good. In 1904 the ground mines of 1873 and the contact mines of 1878 were still in use; the electrical apparatus took its final form in 1888, while Carr's shutter board and test room remained almost unchanged from 1886 onward, a wonderful record considering the modern development of electricity.

The mining defences proved also well adapted to meet varying changes of defence policy caused by development of guns and ships and the ebb and flow of public opinion. Introduced cautiously at first, they were gradually adopted as a cheap means of defence for the commercial ports; then to meet the threat of countermining the minefields were expanded and spread over a larger area, to be again concentrated as countermining proved ineffective. Then to meet the changed conditions of traffic the minefields were altered again, the friendly channels increased in size, or minefields withdrawn in one channel and added in another.

And all such changes were effected with practically no additional cost, except, perhaps, for the construction of a few observing stations.

Compared with the cost entailed by the alteration of patterns of guns, ammunition, and ships, the mines again stand out pre-eminent as an economical form of defence.

It is one of the privileges and responsibilities of the Corps of Royal Engineers to watch the development of experimental science and to apply each invention or discovery towards the extension of the Military Art. The last half-century coincides with the modern growth of the Corps, and coincides also with many extraordinary discoveries in the realm of science.

The development and application of these discoveries has done much to increase the engineering skill and technical knowledge of the Corps, which again has re-acted on every branch of the Army. Of the various forms which this development has taken—telegraphy, submarine mining, electric light, railways, telephony, mechanical transport, and ballooning—submarine mining, though not the first in point of time, was the first technical branch to be organized on a comparatively large scale, and the experience gained in recruiting, training, and maintenance of both officers and men was freely used in the development of other technical corps both inside and outside the Royal Engineers. Of many points which might be mentioned, the principle of local establishments, used for the last 15 years in the Submarine Mining Service, is only just being applied in 1908 to the Garrison Artillery, while the experience of the Submarine Miners with the Auxiliary Forces was freely drawn on recently in framing the Regulations for the Territorial Army.

The work and duty of the Submarine Miners necessarily led them to take a very special interest in the organization and fighting of our Coast Defences, and whatever efficiency these latter have attained can be traced in no small measure to the influence and representations of the various Inspectors-General of Fortifications, especially Sir A. Clarke and Sir R. Grant, and their submarine mining advisers, of whom Lieut.-Colonel R. Y. Armstrong and Major R. M. Ruck were pre-eminent.

From the lengthened controversy dealt with in the early part of this chapter, three definite points emerge which seem worth recording.

First, it is impossible to say that coast defence is solely the duty of the War Office, or solely the duty of the Admiralty. Looked at rightly, the militant organization for the defence of the country must be dealt with as a whole. First come the battle fleets, watching and engaging the enemy's ships, protecting commerce, but unable to prevent the evasion of our fleets by small craft bent on raids. Behind the battle squadrons and linking them to our shores lies a cloud of torpedo craft, including submarine boats. Behind them again come the fixed defence of selected ports, and behind them again come the Home field armies. These latter are on the outbreak of war employed partly in fortresses occupying the land fronts and watching against small raids, partly in movable columns to watch the coast line between the defended ports, and the remainder organized in larger bodies ready to meet any invasion in force or to deliver a decisive blow when the way has been cleared by a naval success.

As long as two different departments, Admiralty and War Office, exist to deal with combatant services, so long must there be an agreement between them as to the interworking of the various parts of the above organization, but in no case will it be possible to draw a hard-and-fast line, and say on this side the Army is responsible and on that side the Navy.

And the second point is that however the duties are divided, a sound organization is the first requisite for success. The term "organization" covers two distinct things, first the careful subdivision of the various duties into groups, so that each group can be entrusted to a homogeneous body of officers and men, who can thoroughly master all the details of their special work and get the maximum value out of the equipment in their charge, and secondly, the careful linking together of these various groups by a specially trained staff and a good system of communicating orders and intelligence.

And the third point is that, given the first two conditions of a good general defence organization, and a good local organization of each fortress, it is not very material how the various groups are labelled, or to apply this to the particular case, whether the Submarine Miners should be called Navy, Artillery, or Engineers, as long as they are employed exclusively on their particular duties, and the general training and work of the Corps ensures the enlistment of suitable men.

But the forces of the British Empire have to be ready for various duties all over the world, so that it is necessary to consider alternative employment for the fortress garrisons in the event of our naval pre-eminence being assured. From this point of view the argument seems conclusive that coast defences should be manned as far as possible by the Army and not by the Navy, as any possible strain on these defences must coincide with a period when the Navy is straining every nerve to attain the command of the sea, and the Army is waiting for that command to be made effective to commence active operations. When the strain on the fortresses can be relaxed, the strain on the Navy will also be much reduced, while the Army will want every possible support, some of which can be obtained from the fortress garrisons.

Our defence organization, by which Garrison Artillery assist the field army with heavy and mountain batteries and in other ways, in which Garrison Engineers are intimately linked with Field Engineers, and in which the infantry and other departments are actually interchangeable with those of the field army seems specially well adapted to meet the special conditions of the British Empire.

CHAPTER VI.

The Homes of the Submarine Miners.—The War Office.—The Inspection Branch.—H.M.S. "Hood."—St. Mary's Barracks.—The Schools at Gillingham, Gosport, and Plymouth. — The Experimental Station. — Brennan Torpedo Factory.

It is of importance to a proper appreciation of the submarine mining work to understand something of the organization at head-quarters, and of the conditions of work at the various schools and other centres.

The branch of the War Office allotted to submarine mining began to take a definite form in 1871, when Lieut.-Colonel Nugent was specially ordered home from Bermuda to take up the work and to act as President of the newly-formed Torpedo Committee.

In 1872 the staff was expanded by the appointment of an officer, Lieut. C. M. Watson, to carry out the inspection of stores at Woolwich. This officer was a member of the War Office and spent one or two days a week at Woolwich on inspection duty.

In 1873 Lieut.-Colonel R. H. Stotherd succeeded Colonel Nugent, and in 1876 was replaced by Lieut.-Colonel W. Crossman who was given the title of "Inspector of Submarine Defences," which title remained unchanged till 1905.

In the same year (1876) Capt. S. Anderson was appointed Assistant Inspector of Submarine Defences, but the appointment lapsed five years later and was not revived till 1886.

In addition to the staff officers there were usually one or more employed officers in the branch; of these, mention may be made of Lieut. M. A. Cameron, who was employed from 1878 to 1880 in editing the first Submarine Mining Manual, Lieut. G. A. Carr, similarly employed in 1888 to 1889, Lieut. C. Penrose, from 1889 to 1891, and Capt. A. H. Randolph, from 1891 onward.

In 1885 Lieut. J. H. Cowan was attached to the branch to control the expenditure on submarine mining establishments, piers, etc., which were being constructed at several stations, but after a few years he was removed to the constructional side of the office of the Inspector-General of Fortifications.

In 1898 the increase of schemes for electric lighting of barracks, and for telegraph and telephone communication, necessitated the employment of a special officer for those duties. Capt. A. M. Stuart was the first officer employed for this purpose, and he was succeeded in turn by Capt. F. Baylay and Capt. A. H. Dumaresq. The most important work undertaken by these officers was the military electric lighting station at Aldershot.

In 1885, on the formation of the Coast Battalion, the senior member of the clerical staff of the Inspector of Submarine Defences, Mr. A. Michie, was given a commission as Lieutenant in the new battalion, and remained in the War Office as confidential Assistant to the Inspector of Submarine Defences and in charge of the office staff. He was succeeded in 1894 by Lieut. J. H. Bailey, who had been trained with the 1892–93 officers' class in submarine mining for service in the Coast Battalion, and has remained in the office till the present day. It is difficult to over-estimate the services of these officers in ensuring continuity in the office and in disposing of the mass of detail inseparable from the administration of a highly technical service.

As the staff of the office was thus built up, the duties and methods were gradually developed, until, when the service was in full working order, the Inspector of Submarine Defences occupied a unique position.

At the present day the tendency of War Office organization is to divide all work into three distinct branches—clear thinking, administration, and inspection, the second of these being further subdivided into two branches dealing with *personnel* and material. The Submarine Mining Office succeeded in combining the three into one group, the Inspector of Submarine Defences being not only the adviser of the Inspector-General of Fortifications on defence questions affecting mine defence, but also the adviser of the Deputy Adjutant-General, R.E., on details of *personnel* such as training and distribution. He also was the final authority on all questions of pattern of stores, arranged for their inspection through the Inspector of R.E. Stores, and administered the funds for the purchase and upkeep of material. The Inspector was an *ex-officio* member of the R.E. Committee and the Assistant Inspector an associate member. In addition to these duties the Inspector or his Assistant inspected all home stations at the time of the annual training, and also the submarine mining volunteer camps.

Besides the information thus obtained a special report was made each year from each station on the annual practice, and also on weekly practices for electric light, etc. These reports were criticized at the War Office and returned to the station with remarks.

By these means a very close connection was maintained between the War Office and all stations, while the Inspector was kept fully acquainted with any special local conditions which affected work or training, and was able to watch the effect of regulations and the efficiency of the patterns of stores and methods of working, so that any defect brought to notice could at once be put right.

The stations once at least in each year got into direct communication with an expert, and were able to discuss with him many questions of detail.

Under this *régime* the service flourished exceedingly.

In 1891 the question was raised whether the Inspector should not be placed under the Deputy Adjutant-General, R.E., rather than the Inspector-General of Fortifications, and a Committee composed of Lieut.-General Sir L. Nicholson, Major-General R. Grant, and Major-General R. Dawson-Scott was appointed to consider this and kindred questions.

They decided that on the whole the administrative work connected with the mining equipment was so important that the office should remain under the Inspector-General of Fortifications, but that the Inspector of Submarine Defences should be recognized as the adviser of the Deputy Adjutant-General on all *personnel* questions affecting the Submarine Miners.

In 1904 the appointment of Assistant Inspector was abolished, and Major Baker Brown was brought into the office as an attached officer. Major Baker Brown succeeded to the charge of the branch in 1905 under the title of "Inspector of Electric Lights and Submarine Mines." The last part of the title was dropped the following year.

The following is a complete list of the officers who held submarine mining appointments at the War Office :—

In Charge of Submarine Mining Branch.

Lieut.-Colonel P. H. N. Nugent	1871-73
Lieut.-Colonel R. H. Stotherd	1873-76

Inspectors of Submarine Defences.

Lieut.-Colonel W. Crossman	1876-81
Major S. Anderson	1881
(Died Sept. 1881).	
Capt. J. T. Bucknill	1881-82
(Acting appointment).	
Lieut.-Colonel E. D. Malcolm	1882-84
Major R. Y. Armstrong (Lt.-Col. July 1886) ...	1884-91
Major R. M. Ruck	1891-96
Major C. Penrose	1896-97
Major F. Rainsford-Hannay	1898-01
Major H. N. Dumbleton	1901-05

Assistant Inspector of Submarine Defences.

Capt. S. Anderson (Major Sept. 1879)	1876-81
(Appointment abolished).	
Capt. (local Major) R. M. Ruck (Major Dec. 1889)	1886-91
Capt. (local Major) C. Penrose (Major July 1893)	1891-96
Major P. R. Burn-Murdoch...	1896-00
Major A. H. Randolph	1900-02
Major H. V. Kent	1902-04
(Appointment abolished).	

Inspector of Electric Lights and Submarine Mines.

Major W. Baker Brown	1905

The Staff for the Inspection of Stores at Woolwich started in 1871 with a detachment of Submarine Miners under Lieut. Scott, who was replaced shortly afterwards by Lieut. C. M. Watson. They were employed at first receiving, inspecting, and despatching to stations various submarine mining stores, but were soon called on to carry out other similar duties, notably the despatch of telegraph and other R.E. stores to Ashantee in 1873, including a light railway. The details of a balloon equipment were worked out, but this was not sent.

The officer in charge remained in the position of an employed officer at the War Office till 1st April, 1889, when Capt. H. E. Tyler was appointed a 2nd Class Assistant Inspector of R.E. stores of the Army Ordnance Department, being raised to the position of 1st Class Assistant Inspector in 1891 ; he was the first officer to reside at Woolwich, though he continued to attend at the War Office.

In 1896, on the reorganization of the Army Ordnance Department, Capt. A. M. Stuart replaced Capt. Tyler and became an Inspector under the Army Ordnance. The office reverted to the control of the Inspector-General of Fortifications in 1901.

The staff was extended in 1894 by the appointment of an officer of the Coast Battalion as Assistant to the Inspector, the first officer so appointed being Lieut. W. Montgomery, who was succeeded in 1897 by Lieut. G. Etherington.

In 1900, the duties having become more extensive, the officer of the Coast Battalion was replaced by an R.E. officer specially trained in mechanical engineering, Capt. R. H. Lewis being the first officer selected for the appointment.

The arrangements for the inspection of stores were little affected by the abolition of submarine mining, as the developments of electric lighting and telegraph and telephone equipment nearly compensated for the withdrawal of the mines.

The following submarine mining officers have held this appointment :—

Lieut. C. M. Watson	1873-74
Lieut. D. O'Brien	1874-76
Lieut. G. Barker	1876-77
Lieut. J. T. Bucknill	1877-82
Lieut. E. F. Rhodes	1882-85
Capt. F. Rainsford-Hannay	1885-89
Capt. H. E. Tyler	1889-94
Capt. A. M. Stuart	1894-98
Capt. H. M. Wade	1898-01
Capt. H. G. K. Wait	1901-06

In the early days of submarine mining the detachments employed lived in Brompton Barracks and marched to Gillingham for work.

In 1866 an old hulk—the corvette *Volta*—was moored in the

Medway, which became known as the Floating Electrical School, and formed a centre for the submarine mining work and experiments.

When the first Submarine Mining Company was formed its headquarters were in the North Square, Brompton Barracks.

H.M.S. *Hood* became the home of the Submarine Miners at Chatham in 1873, and was occupied in August of that year by the 4th and 33rd Companies.

She was one of the last of the wooden line-of-battle ships built about 10 years before, and was reputed to have been strained in launching, and so had never been equipped for sea.

The general arrangements on board were somewhat as follows:—

The upper deck was chiefly used as a parade.

The forecastle contained the men's ablution rooms and other arrangements, while the Officers' Mess and cabins were under the poop aft and communicated with a stern walk.

The main deck was utilized for offices, stores, guard-room, instructional test rooms, fitting rooms, and one or two cabins.

The lower deck was fitted as a large barrack room for the men, with the sergeants' accommodation and mess aft.

Below this was the orlop deck, used entirely for submarine mining purposes, with two large baggage ports, from which gear could be got out on to the submarine mining vessels.

In the hold, besides an enormous quantity of round shot for ballast, were the boiler and other appliances for heating the ship.

Externally, the vessel presented a somewhat dishevelled appearance, as painting was carried out only once in four years according to the barrack routine.

Internally the condition was worse, as painting was only due at seven years' interval.

There was living accommodation on board for five officers, each officer getting a cabin $12' \times 7' \times 6'$, for which he paid 10d. a day "barrack rent."

Officers for whom no quarter could be provided used to live at Brompton Barracks and go down to the *Hood* daily, and there was also a *Hood* room in barracks, with the essential barrack furniture, where an officer could sleep if he failed to rejoin the ship.

The vessel was moored fore and aft with bows towards Gillingham Pier, and about a quarter of a mile to the east; astern of her was an old mortar boat used as a magazine.

In addition the old corvette *Volta*, a miner, launch, some lighters, and small boats were moored between the *Hood* and the south shore of the Medway.

During the day a regular boat service was run between the shore and the *Hood*, and at night a boat's crew was kept ready to man a cutter, gig, or dinghy, according to the size of the parties to be conveyed.

H.M.S. "Hood" lying off Gillingham, 1873—1883.

The *Hood* was connected by electric cable to the shore, and thence to the Telegraph School, Brompton Barracks, so that messages could be sent and received to any part of the world.

There was also a bell circuit terminating on two metallic contacts let into a telegraph post on shore; these, if joined by a knife or coin, completed a circuit and rang a bell on the ship.

It is on record that a friend of one of the officers, who had not an intimate knowledge of electricity, returning one night after a dance, tried to bridge the connection with a £5 note, and was surprised at not obtaining the result he expected!

On the whole, the accommodation on the *Hood* would be considered nowadays very rough, but it bred a hardy race and instilled into all ranks a practical knowledge of water work, difficult to get in any other way. But as a school of electrical science it was very defective. Not only was it very dirty, but the orlop deck was very dark, and it was sometimes necessary to remove the glass from the galvanometer and feel the needle to see if it were deflecting! Accurate work was impossible under such conditions, and it is surprising how the electrical apparatus progressed at all. But the little group of officers thrown together in a little kingdom of their own were generally a cheery party, and many stories of the *Hood* were current in the later days. On one occasion an officer got very irate at the orderly bugler sounding the reveillé just outside his cabin, and rushed out to find the bugler sounding away dressed in Nature's uniform. His excuse was it was very hot on the men's deck! One year the officers, led by Dumbleton, erected an equatorial telescope, with which they were able to locate the planet Venus in broad daylight, no mean feat even on a stable platform. In 1882 parts of the vessels were lit with electric light, derived from a small steam engine and dynamo in the hold. The orderly officer going the rounds at night after 11 p.m. had a very uncomfortable time, especially if above the average height, as all lights were out and the decks littered with gear, so that damaged forage caps and sore heads were not infrequent.

In the midst of the congestion of stores McCulloch, the Quartermaster, was in his element, and he not only succeeded in handing back the ship to the Admiralty without serious discrepancy, but also succeeded in satisfying Mr. Jay, the War Office auditor, who came to take stock of the vessel and submarine mining equipment. Among other items on charge were some 20,000 round shot and 20,000 brass plugs. McCulloch gravely explained that the shot were stored in the hold as ballast, and that each shot had a plug, and on Mr. Jay expressing a wish to count them, promised him all the assistance in his power. But on his first visit to the hold the luckless auditor slipped, sprained his ankle, and nearly cracked his skull, whereupon his zeal evaporated.

When the old ship was finally dismantled by convicts after 1883, these round shot were removed and counted, and proved absolutely correct.

About 1880 the first beginning was made with the buildings on shore at Gillingham, the block facing the public road being erected and used for some time for the instruction of electricians' classes. A great part of the land on which the school was subsequently built was then a mud flat, submerged at high water. At that time the extension of Chatham Dockyard was still in progress, and the hill-side below St. Mary's Barracks, now occupied by naval barracks, was being levelled by convicts. Arrangements were made to bring some of the surplus earth to Gillingham, and under McCulloch's supervision the flats were gradually reclaimed, a parade was formed, and a block of offices, some cable tanks, and two mine stores were built by convict labour. As the mud promised no sure foundation, these buildings were "floated" on thick concrete slabs about 18″ thick, a system which proved thoroughly sound in practice.

In 1883 it was decided to surrender the *Hood* and move the head-quarters of the Submarine Miners into St. Mary's Barracks. These were of the old casemated type, with two tiers of casemates built inside a bastioned front, which formed the north-eastern corner of Chatham Lines. The rooms were thus like sections of a tunnel, long and dark, with light at one end only, and with very inadequate arrangements for heating and ventilation. It was about a mile from Gillingham Pier, and this distance had to be marched there and back twice a day by all ranks. An attempt was made to use a narrow-gauge railway, but an accident to a train in which a Volunteer Sub-marine Miner was injured put a stop to the experiment.

After the cramped accommodation on the *Hood*, the casemates seemed unduly spacious, and in 1885, when an augmentation took place in the numbers, the Officers' Mess was still occupying only the front portion of the rooms allotted for dining and ante-room, the back of each being an expanse of bare boards.

Up to this time the Mess had been treated as a detachment Mess from the headquarters in Brompton Barracks, but in this year they were separated. The St. Mary's Mess received a sum of money representing the subscriptions paid by the officers for the previous two years, two worn-out armchairs, and an old carpet, and were allowed to keep the small amount of furniture already in possession. The officers remained honorary members of the Brompton Mess, to which they paid a small subscription.

The St. Mary's Mess was not allowed to charge an entrance fee, but by the exercise of some self-denial and a little cheeseparing, managed to accumulate enough funds to completely furnish the Mess and increase the equipment, till it was able to provide for a dinner of 30, which number not infrequently sat down on guest nights.

One important feature was the possession of a Government billiard table, on which Dumbleton could give any member of the Mess 30 in 100 and a beating. Another was the commencement of a reading library, stocked with standard books. The Balloon School and Factory was at that time located in St. Mary's Barracks, and soon after the Submarine Miners went in, the plant of the Electrical School was moved from some old sheds at the back of the Institute to the central casemates at St. Mary's, while a year or two later the first Brennan Factory was established near the corner of the Convict Prison. The officers from all these establishments frequently lunched at the St. Mary's Mess, and the latter was also used by classes of Line officers under instruction at the S.M.E.

On the whole it was a pleasant community, where junior officers, coming for a course after their two years of tuition at Brompton Barracks, were received with a hearty welcome, and soon found themselves at home. All expenses were shared in common, and a great feature was the afternoon tea, with a liberal allowance of cake; but in spite of this extravagance (which nearly broke the heart of the messman) the daily rate of messing rarely exceeded 3s. 6d. At first beer was provided as part of the daily ration, in spite of the protest of the one teetotaller. The majority argued with some truth that the minority of one more than made up any loss in beer by his hearty appetite, but had to submit to the *Queen's Regulations* when they were quoted by the Colonel.

The R.E. Golf Club was started by the St. Mary's Mess in 1886 when, under the auspices of Lieut. W. F. Hawkins, a course was marked out and each member of the Mess was detailed to prepare a green. One energetic member, renowned for his accuracy, produced a green about 6′ in diameter, perfectly circular, with a jam pot let into the centre, and the surface well rammed till it was about 2″ or 3″ below the surrounding ground! At first play took place with iron clubs only, but the advent of an infantry officer who owned a driver opened a vista of better things, and thenceforward progress was rapid. The course was a very sporting one, and hazards were frequently added by classes under instruction in fieldworks, but it produced some good golfers. It is worth mentioning that the handicap was regulated by a geometrical curve, of which the "X" represented the best score made on the full course by any individual and "Y" gave his handicap. On one occasion a beginner under this system received a handicap of 110 and romped home easily, but on the whole the results worked out wonderfully closely, and the Saturday handicaps were a feature of the club.

While the officers and men had been shaking down in barracks, the school buildings at Gillingham had been growing apace.

Towards the end of 1885 the Inspector-General of Fortifications came to make an inspection, and the day turning wet, the whole of the men under instruction, about 120 of all ranks, were packed into one of the mine stores, the only building where they could obtain cover. On the arrival of the Inspector-General of Fortifications, accompanied by the senior officers of the S.M.E., this seething mass of men was duly called to attention, and when the astonished Inspector-General of Fortifications asked what they were doing, Colonel Clayton replied, "They seem to be trying to stand upright, sir!" The next day a sum of £700 was placed at the disposal of the Commandant, and within a month four large drill sheds of corrugated iron had been erected. At the same time a definite plan for future extensions was arranged, a central avenue was laid out, and later planted with trees, the system of 18″ tramlines was marked out, paths and parades levelled, and surface drainage provided. As the work extended more buildings were added year by year, notably two complete blocks for the instruction of electricians, each containing a test room, fitting room, and class room, and also a series of loading sheds. The eastern arm of the camber had been leased in 1883 from the local authorities and a pier constructed.

The water work was done mainly in a minefield near the old site of the *Hood*, where moorings were laid for the miner and other boats. There was also a minefield between Hoo and Darnet Forts, with test rooms in the forts. These were used for practical instruction in testing mines, while each officers' class had to arrange a small minefield and survey a system of alignments.

In 1892 it was decided to open additional schools at Gosport and Plymouth.

The submarine mining work at Gosport commenced in 1873, in which year the test-room was in Fort Gilkicker, and an old shed at Stokes Bay, erected by the contractors while building the outer forts, was used as a store. A submarine mining establishment for the defence mines was then built at Fort Blockhouse, which became the centre of the R.E. work, while Fort Monckton was the home of the Southern Submarine Mining Militia.

From 1883 onwards a large detachment of officers and men used to go yearly from Chatham to Portsmouth for a rough-water class. These worked both at Spithead and in Stokes Bay, and gradually, for their accommodation, an establishment of buildings was provided at the latter with a good pier. This establishment was built on the general arrangement which had been found suitable at Gillingham; the buildings were arranged round three sides of a rectangle, the stores and workshops on one side, the class rooms and offices on the other, connected at the end by the mine store and loading shed. The fourth side was occupied by cable tanks and the pier. The parade was covered with 18″ tramlines, which were connected with Forts Monckton and Blockhouse by an 18″ railway, on which ran a couple of small locomotives. The school buildings were thus ready and complete when the new school was started in 1892, but in order to get the men nearer their work the R.E. companies were moved from Fort Blockhouse to Fort Monckton, the former becoming the home of the Militia.

Fort Monckton is an interesting example of the style of fortification of the early part of the 19th century. It is a detached fort with a bastioned trace, a deep dry ditch with full escarp, and outside that a wet ditch. Inside there were the usual two-storied casemates, the lower floor dark and damp, the upper floor just habitable.

It is noteworthy how all over the world the submarine mining units had to live in old and inconvenient barracks; but this is not remarkable, as there are necessarily a large number of unoccupied forts round our coast—the remains of previous schemes of fortification—and these have to be used as barracks. Many makeshifts and not a little ingenuity were required to make the accommodation at all fit to live in, and to provide Sergeants' Mess, married quarters, and all the accessories of military life, but on the whole the Submarine Miners managed to overcome these material obstacles, and it used to be a commonplace remark with Inspecting Officers how well the barracks were kept.

A small Officers' Mess was formed in Fort Monckton for use of the officers' class and attached officers.

The mining work at Gosport was at first done largely at Stokes Bay, where a minefield of nearly 100 mines was kept going in connection with instruction. The test room and firing station was in the Stokes Bay establishment, which enabled instruction in all branches to be carried out simultaneously.

The defence minefield at Spithead was used during the Militia practice, and a large part of the defence was laid out each year, and latterly the defence minefield of Southampton Water was also used for the same purpose.

At Plymouth the conditions were rather more difficult; the submarine mining establishment at that station was not built till about 1882, when the wharf at Fisher's Nose, on the eastern side of Devonport, close under the Citadel, was allotted for the purpose. There were already constructed some blocks of barracks called Elphinstone Barracks, and blocks of submarine mining buildings—mine stores, electrical rooms, and offices gradually grew up on a steep slope at the foot of the Citadel. There was no Officers' Mess. But though the barracks and school buildings were thus close together, there was no possibility of obtaining a practice minefield in the immediate vicinity, and all water work had to be done in the defence minefields, or under

Picklecombe Fort, near the western entrance of the Breakwater. Also the submarine mining vessels could not come alongside the wharf at low tide, so that a good deal of the work was done from lighters, which were loaded at high tide and then towed off to moorings.

The practice minefield was somewhat exposed and got the benefit of the Atlantic swell, so that the conditions of water work at this station were more severe than at either of the other schools.

But though the conditions varied, the general system of instruction was much the same at all three stations. One feature common to all was the number of different subjects which had to be taught, each subject requiring different treatment and a separate staff. There was first of all the ordinary submarine mining course, which all officers and men experienced. Then there was the course in the electrical work connected with mining and electric lighting, which was taught to all officers and to selected men. Then the course of engine driving, with the marine engines on the vessels and launches and with stationary engines on shore for electric lighting, steam hoists, and similar duties. This included the repair of all parts of the machinery or even larger jobs, such as removing and re-tubing a boiler, or drawing and exchanging the propeller shaft. Engine driving was taught to selected men only.

Then there was a long course of instruction for a few men of suitable trades in repairing electrical instruments, so as to enable each station to be fairly independent in this respect. And also a course of diving taught to a few men, not as in the early days to check the position of mines, but to examine vessels' bottoms, clear fouls on propellers, recover mines and cables which had broken adrift, and carry out under water repairs to piers and wharfs.

On the introduction of the Brennan torpedo, a special course of instruction was arranged for handling the mechanism and looking after the gear, while selected engine drivers were taught to use the special apparatus fitted in the Brennan engine room. This work was especially confidential, and every officer and man had to sign a declaration of secrecy.

In addition there were similar shortened courses in many of these subjects for Militia and Volunteer officers and men.

On the reorganization of the schools in 1892 it was decided, in order to save duplication of staff, that all instruction in instrument repairing, diving, and Brennan work should continue to be done at Chatham. On the other hand, the instruction of the officers' classes was withdrawn from Chatham and divided between Portsmouth and Plymouth, so that two classes of four officers each were trained each year. As young officers join the Engineers from the R.M. Academy half-yearly, this arrangement fitted in well in other respects.

The staff at Portsmouth and Plymouth was so organized that the Chief Instructor was also in command of the company and of the defence mines and lights. A good deal of his time each day was thus taken up with office duties, and his instructional work was necessarily limited to supervision and organization, the issue of daily orders, and the charge of any big day on the water. The Assistant Instructor under him was in direct charge of the instructional establishment, gave personal instruction to the officers' class, and watched the instruction and carried out the practical examination of the young soldiers and electrician classes. He was assisted by one of the subalterns of the company. Of subordinate staff, there was a sergeant-major in general charge of the barrack and school, and two quartermaster-sergeants for the ordinary submarine mining instruction. For the electrical course two mechanist electricians were provided, who divided the work between them. The arrangement for the instruction of engine drivers was rather different; the detailed instruction was given by mechanists as for the electrical class, but the general supervision was carried out by an officer with his headquarters at Chatham, who divided his time between the three schools.

In the early days of submarine mining the instruction of engine drivers was carried out at Woolwich under the Superintendent of Machinery, an office subsequently merged into that of Superintending Engineer and Construction of Shipping, as the duties became more directly connected with the military water transport. This arrangement did not prove satisfactory, and when the responsibility for the submarine mining boats was taken over from the Admiralty, a retired naval engineer officer, Mr. J. Parry, was appointed Superintendent Submarine Mining Machinery at Gillingham, to take charge of the instruction of engine drivers and to advise the War Office as regards the repair and maintenance of the marine machinery. In both capacities he proved of great assistance, keeping the instruction of engine drivers up to a high standard. He also suggested several improvements in the boats, notably a special form of bow derrick, which was in use for many years.

When the schools were divided arrangements were made to continue to utilize Mr. Parry's services, and he used to make periodical visits to the other two schools to examine engine drivers. At the same time he gradually relinquished the inspection of the machinery which devolved on the S.E.C.S. at Woolwich.

On Mr. Parry's retirement in 1900, Mr. J. Bell, R.N., took over the instructional duties, with headquarters at Portsmouth, where there were a large number of defence electric-light engines on which his services could be utilized.

The submarine mining work at Chatham was rather different to that at the other schools. At first an attempt was made to amalgamate the regimental and instructional duties, but not very successfully, as the R.E. at Chatham had a battalion organization, and thus the Chief Instructor did not get the free hand in the disposal of his men which was obtained at the other schools. Also the Chatham School had rather more than its proportional share of the stations allotted to it, had three special branches of instruction in subjects not taught at the other schools, and the Chief Instructor at Chatham was a member of the R.E. Committee. There was also very little assistance obtainable from the officers of M Company, so that altogether the Chief Instructor found his time fully occupied with the school work.

Of the three special courses, instrument repairing was taught by a sergeant-major mechanist, first by Sergt.-Major Castell and later by Sergt.-Major Vandell, both experts in their particular line. Both rendered great assistance in the preparation of patterns for the R.E. Committee. Diving was taught by special N.C.O. instructors, of whom F. and M. T. White were the best known. The standard of this work was very good.

The Brennan work was under a special Assistant Instructor and was done partly at the factory at Chatham and partly at Sheerness; for the latter the officer and party had to go down by launch from Chatham, while one of the Quartermaster-Sergeant Instructors, with a caretaking staff, lived at Sheerness to look after the gear. As the Brennan work developed, a class of Brennan mechanists was formed, and then two of these were detailed to carry out the instruction.

The last Submarine Mining School to be started was that for Brennan work at Sheerness on 1st April, 1901. Capt. W. L. Palmer was the first Instructor and he was assisted by one of the company officers. The School proved a success, and from 1901 to 1906 turned out 28 officers and 53 men, against 40 officers and 125 men trained in the previous decade.

One other detail of the work of the Submarine Mining Schools may be mentioned, and that was the close touch maintained with the men after they had finished instruction, by means of the system of qualification reports. These were forms on which were recorded the detailed qualification of each man after each part of his special course, and his final general qualification was assessed on completion of the whole. If subsequently a man had improved his knowledge as the result of experience and practice, the officer commanding his company amended the detailed qualifications and forwarded the form for the Chief Instructor to assess the general qualification. The latter officer often checked the details by setting a small examination, theoretical or practical, to see if a good standard was being maintained, and if this was satisfactory, recorded a higher general qualification.

As this latter had to be obtained before an increase of Engineer pay could be granted, the system proved an incentive to learning and also a safeguard against too low a standard at out-stations.

Another point which may be noticed here is that all men were taught to swim, and could not be raised a rate of Engineer pay until they could pass a certain test—swim 100 yards and keep afloat for one minute with clothes on.

The following is a complete list of the officers who held appointments on the instructional staff:—

CHATHAM TELEGRAPH SCHOOL, S.M.E., 1866—1884.

Instructors.

Capt. R. H. Stotherd	1866-71
Capt. E. D. Malcolm	1871-76
Capt. R. Y. Armstrong	1876-83
Capt. P. Cardew	1883-84

Submarine Mining instruction separated from Electrical School.

Assistant Instructors for Submarine Mining.

Lieut. R. Y. Armstrong (Capt. Aug. 1872) ...	1871-76
Lieut. J. T. Bucknill	1876-77
Lieut. G. Barker	1877-81
Lieut. R. M. Ruck (Capt. 1883)	1881-84

Temporary Assistant Instructors.

Lieut. Renny-Tailyour	1875-77 & 79
Lieut. G. A. Carr	1880
Lieut. H. N. Dumbleton	1883

CHATHAM SCHOOL OF SUBMARINE MINING, S.M.E., 1884—1892.

Assistant Instructors in Charge.

Lieut. R. M. Ruck	1884-85
Lieut. G. A. Carr	1885-86

Instructors in Submarine Mining.

Capt. A. T. Preston (Major July 1887)... ...	1886-91
Capt. H. B. Roberts (Acting)	1891-92

Assistant Instructors.

Lieut. G. A. Carr (Capt. Aug. 1887)	1886-88
Lieut. H. N. Dumbleton (Capt. April 1888) ...	1885-90
Lieut. F. R. Reynolds (Capt. April 1888) ...	1888-91
Lieut. W. G. Lawrie (Capt. Oct. 1891)	1890-92
Lieut. E. C. Seaman (for Brennan Torpedo) ...	1890-92
Capt. H. B. Roberts	1891-92

Temporary Assistant Instructors.

Lieut. W. Baker Brown 1885-88
Lieut. H. B. Roberts (Capt. April 1889) 1888-91
Lieut. W. P. Brett (Capt. Dec. 1891) 1891-92

Chatham School of Submarine Mining, 1892—1905.

Chief Instructors.

Capt. G. A. Carr (Major July 1895) 1892-96
Capt. W. Baker Brown (Major April 1900) ... 1896-01
Capt. G. P. A. Acworth (Major Nov. 1904) ... 1901-05

Assistant Instructors.

Lieut. E. C. Seaman (Capt. Jan. 1896) 1892-97
(For Brennan Torpedo).
Capt. H. B. Roberts 1892-96
Lieut. G. P. A. Acworth (Capt. Nov. 1896) ... 1896-00
Capt. C. B. Collins (for Brennan Torpedo) ... 1897-01
Lieut. G. Durnford (Capt. Aug. 1904) 1900-05

Portsmouth School of Submarine Mining, 1892—1905.

Chief Instructors.

Capt. W. Sealy Vidal 1892-94
Capt. W. Baker Brown (Acting) 1894-95
Capt. H. N. Dumbleton (Major July 1896) ... 1895-01
Capt. C. B. Collins (Major Nov. 1904) 1901-06

Assistant Instructors.

Capt. W. Baker Brown 1892-96
Lieut. J. W. S. Sewell (Acting) 1894-95
Lieut. E. H. Haig (Capt. Nov. 1897) 1896-00
Lieut. J. R. Garwood 1901-06

Plymouth School of Submarine Mining, 1892—1905.

Chief Instructors.

Capt. M. A. Boyd 1892-97
Capt. F. L. Lloyd 1897-00
Capt. E. H. Haig 1900-05

Assistant Instructors.

Capt. W. G. Lawrie 1892-95
Capt. F. L. Lloyd 1895-97
Capt. W. M. Pyne 1897-02
Lieut. F. W. Robertson (Capt. Nov. 1905) ... 1902-06

Sheerness School for Brennan Work.

Instructor.

Capt. W. L. Palmer	1901-06

Temporary Assistant Instructors.

Lieut. C. S. A. Akerman	1901-05
Lieut. M. G. Taylor	1905-06

The Chatham School was closed in 1905 and the Sheerness School in 1906. The Portsmouth and Plymouth Schools were re-formed as Schools of Electric Light in 1906.

In the early days the experimental work was done at any convenient station, first at Chatham, then at Portsmouth, and then at Pembroke, sometimes at all three together.

In 1878 important countermining experiments were carried out at all three.

In 1882 Capt. F. R. de Wolski carried out a series of experiments at Hurst Castle.

In 1885 and the following years Capt. H. E. Tyler, using Plymouth as headquarters, carried out some very valuable experiments, especially a series at Cardiff to determine the effects of countermines on target mines.

In 1889 Capt. W. Sealy Vidal took charge of the work at Plymouth, and in 1890 was definitely appointed Experimental Officer for the Submarine Mining Service. Later in the same year he moved to Gosport and took charge, in addition to his experimental work, of the instructional establishment at Stokes Bay.

In 1892, on the reorganization of the schools, the experimental establishment was moved to Pembroke Dock, where the duties of experimental officer were combined with the charge of the mine defence and the command of the 35th Company.

The officers who have held this appointment are :—

Capt. W. Sealy Vidal	1890-92
Capt. P. R. Burn-Murdoch (Major Sept. 1896) ...	1892-96
Capt. Le Breton Simmons (Major Nov. 1901) ...	1896-02
Capt. W. M. Pyne	1902-04

The appointment was abolished 1904.

The last establishment of the Submarine Miners to which reference must be made is the Brennan Torpedo Factory.

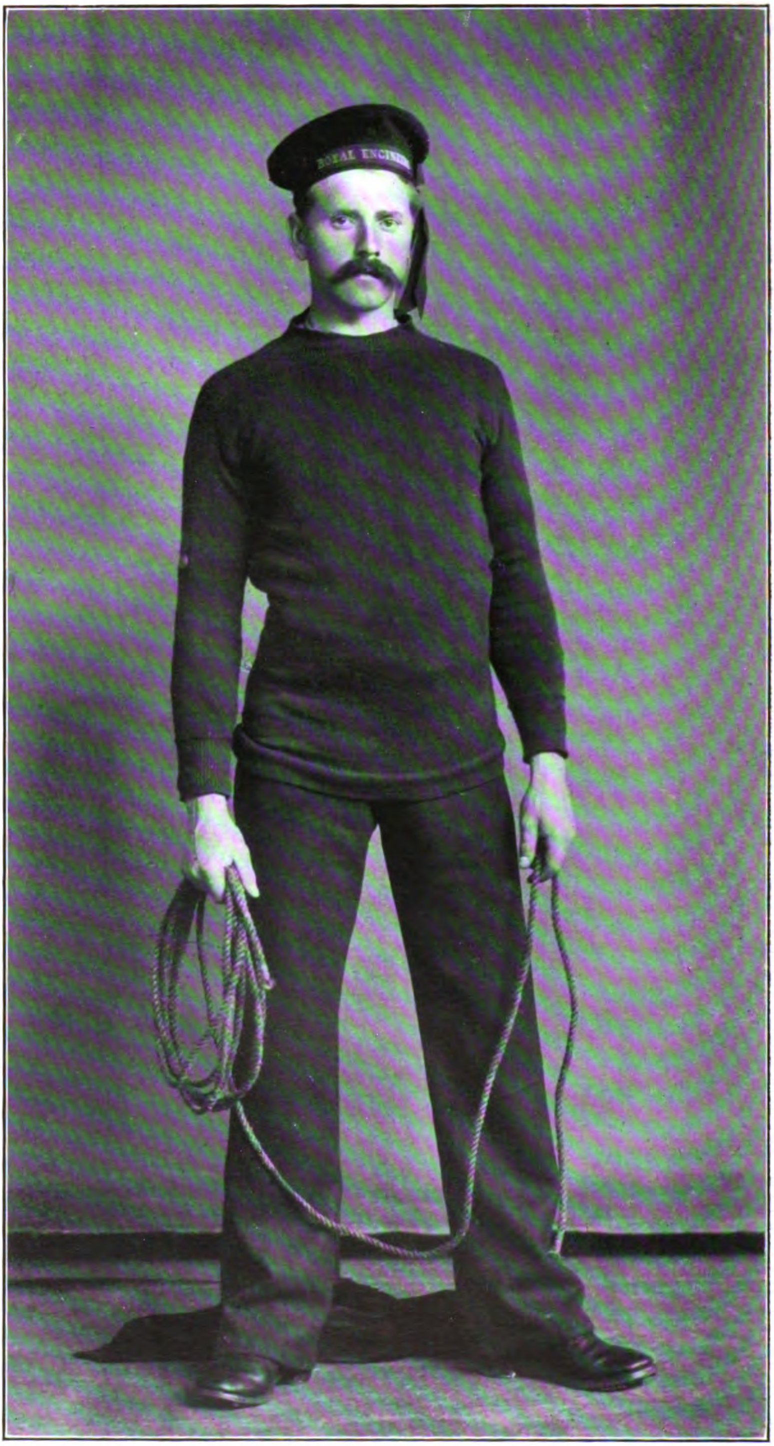
This was first established on the ground in front of St. Mary's Barracks, on a site now covered by naval buildings, and on the purchase of the torpedo in 1887, Mr. Brennan himself was made the

Superintendent of the factory. On completion of his engagement in that capacity he was retained as adviser and in charge of the design branch, and Major MacAdam was appointed to the charge of the factory in 1895. Soon after this a new building was erected in the submarine mining enclosure at Gillingham.

In 1903 Major MacAdam handed over charge to Capt. E. C. Seaman, who resigned the following year and was succeeded by Capt. C. F. Rundall.

In connection with experiments carried out in the use of a thicker wire, which involved the re-designing of every part of the torpedo, a vessel was purchased and named the *Sir Howard Elphinstone.* This was fitted with engines as a floating installation, and not only proved well adapted for experiments, but showed that the torpedo could be successfully run from a ship.

These experiments were at first in charge of the Assistant Instructor for Brennan work, and as the experiments got more numerous, it was necessary to give extra assistance to this officer, and Lieuts. A. D. Carden and C. S. A. Akerman were successively employed on this duty. On the formation of the new Brennan School in 1901 a special officer was appointed for Brennan experimental work and attached to the factory staff. Lieut. C. F. Rundall was the first officer so appointed, and he was succeeded in 1904 by Lieut. P. Campbell till 1906, when the appointment was abolished.



Working Dress I.

CHAPTER VII.

THE "PERSONNEL" OF THE SUBMARINE MINING SERVICE.—OFFICERS.—SUPERNUMERARY LIST.—RANK AND FILE.—THE REGULAR COMPANIES.—COAST BATTALION.—EASTERN BATTALION.—LOCAL COMPANIES ABROAD.

THE *personnel* of the Submarine Mining Service was the subject of many experiments, some of which led up to changes in other branches.

The officers of the regular branch of the service were drawn from the Corps of Royal Engineers. They were trained at first in the full course laid down for R.E. officers at the S.M.E., Chatham, to which was added a special course of Submarine Mining. Later this was thought to give too long a total period of training, so that the course for R.E. officers at the S.M.E. was divided into two parts, and officers selected for the submarine mining course only went through Part I. at Chatham. But all submarine mining officers were considered qualified for any ordinary R.E. work, though only the specially trained officer could undertake submarine mining duties. An idea thus arose that the submarine mining officer was trying to shirk his share of barrack repairs. The fact was that the requirements of his special military work were very heavy, and at certain periods of the year occupied the whole of his time, so that it was impossible for him at the same time to construct forts or repair barracks. Nowadays the necessity of giving some part of the year entirely to military training is recognized in all arms of the Service, but it may fairly be claimed that the submarine miners were some years ahead of the Army in the careful arrangements made for this annual training.

Several proposals were made to form the Submarine Mining Service into a separate corps, with the object of concentrating the special training and so obtaining greater efficiency, but all these proposals broke down on examination. The difficulty, which applies to other branches of the Engineers, was that the submarine mining work necessarily involves the employment of a number of small units working each at a different station. There is little opportunity of combining these into any larger organization than the company, and thus there would be great difficulty in providing employment for the higher ranks of major and lieut.-colonel, while a service without a due proportion of such ranks would fail to attract officers. By keeping the officers part of the Corps of Royal Engineers this difficulty was overcome, as officers on promotion could take their turn in charge of the Engineer districts or sub-districts, where in many cases their special knowledge proved very useful.

A proposal was made to station a lieut.-colonel in each command at home to act as a sort of staff officer for the submarine mining defence, but it was never made effective. An attempt was also made to establish a battalion organization at Chatham and Gosport. Both these failed, as shown in the earlier chapters.

The Supernumerary Staff of the Submarine Mining Service consisted of two classes—mechanists and storekeepers.

The development of the first of these, dates from Lord Sandhurst's Committee of 1886, as though a few mechanists had been appointed before this to assist in the supervision of machinery generally, they were not employed on submarine mining duties. Lord Sandhurst's Committee recommended three classes, with establishments as under:—

Mechanists	28
Electricians	48
Masters of vessels	24

but soon after the title of mechanist was made common to all three, and the different classes were known as mechanist engine driver, mechanist electrician, and mechanist coxswain.

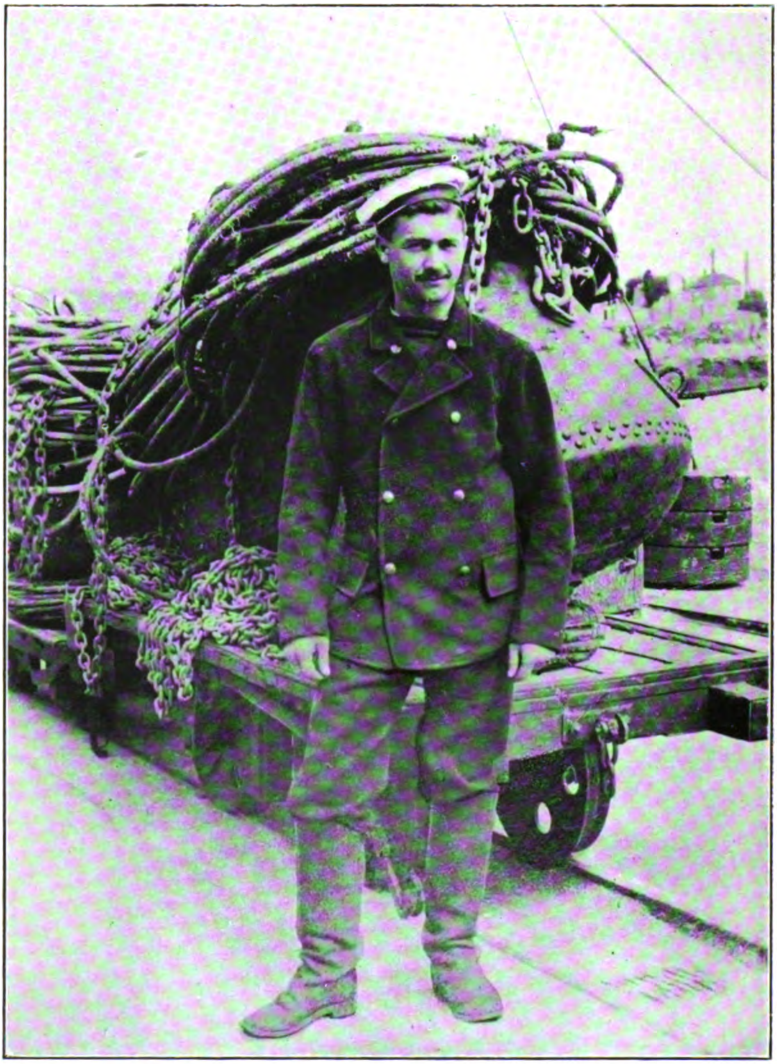
A few years later the position of Mechanist Instrument Repairer was granted to the senior N.C.O.'s of this branch at Chatham, Portsmouth, and Plymouth, and on the development of the Brennan service a class of mechanist for this work was introduced in 1898.

The total establishments in 1904 were as under:—

Coxswains	28
Electricians	61
Engine drivers	46
Instrument repairers	3
Brennan workers	9

As mechanists had to superintend working parties and required special rates of pay to attract suitable candidates, they were given a fairly high military rank, commencing on appointment with the rank of company sergeant-major (later transformed into staff-sergeant), and were promoted after six years' service, if otherwise qualified, to the rank of quartermaster-sergeant. Further promotion was by selection to warrant rank as sergeant-major.

Mechanists were selected mainly from N.C.O.'s of good character



Working Dress II.

and special technical attainments, but a few civilian engine drivers were enlisted as mechanists, and the majority of the coxswains were brought in from outside. These latter, being employed solely on the vessels, received very little military training and were not armed. The remainder were armed and equipped as the higher ranks of the Royal Engineers, and except that they could not command on regimental parades or preside at mess meetings, were treated in the same way as other N.C.O.'s.

The class of storekeepers was instituted to provide selected N.C.O.'s to take charge of submarine mining stores at stations. It was expanded in 1886, and in 1904 reached a total of 32. The position, rank, and promotion of these N.C.O.'s were the same as for mechanists. It may be noted that the distribution of both mechanists and storekeepers was on a station basis; they did not belong to any regimental unit, and did not change stations with the units.

The rank and file were recruited in the same way, and the organization of the companies and ranks was the same as in other dismounted units of the Royal Engineers. On enlistment all recruits went through the recruit's courses of drill and musketry at Chatham, on completion of which a certain number either volunteered or were selected for training as submarine miners. Only certain trades were taken, and the proportion of the different trades was adjusted as far as possible to suit the numbers required for training in special classes.

In addition to the ordinary red uniform each man had a working dress of blue serge trousers and coat, a blue jersey, pea jacket, and sailor's round cap, with Canada pattern knee boots. This made a very effective kit, and was thoroughly suited for the work. A similar dress was worn by officers and Supernumerary Staff.

The proportion of the various non-commissioned ranks was always very high on account of the necessity of supervising so many auxiliaries and native companies. Also the fact that the nature of the work threw all ranks into very close contact produced a strong *esprit de corps* and very friendly relations between officers and men, while the presence of a large proportion of men of high technical qualifications and general intelligence caused a marked absence of military crime, which was noteworthy even in such a well-conducted corps as the Royal Engineers.

The gradual growth of the Royal Engineer companies allotted to submarine mining duty has been described in the earlier chapters. Of the 13 regular companies which formed the backbone of the service on its abolition in 1904, seven were in existence prior to the commencement of submarine mining, and were converted by the substitution of officers, N.C.O.'s, and men trained in submarine mining for the *personnel* trained in purely corps duties. A nucleus of N.C.O.'s was however generally transferred with the unit, and were trained to submarine mining duties.

These seven companies were the 4th, 21st, 23rd, 27th, 28th, 30th, and 33rd. Many of these had distinguished records.

The 4th Company served in the Crimea in 1855 under Capt. Craigie, and in the Crimea and Indian Mutiny under Major Nicholson (afterwards I.G.F.).

The 21st Company served in the Indian Mutiny under Capt. Neville.

The 23rd Company was first raised in April, 1855, to form the nucleus of an Engineer train, and was converted into the A Troop in 1856. A new 23rd Company was then raised, and in 1857 was ordered to China, but was diverted to India on the outbreak of the Mutiny. It joined the army in China in December, 1859.

The 27th and 28th Companies were formed in 1856. The former has no record of war service; the latter served in the Ashantee War of 1873–74 under Major Jones, being the only R.E. unit with the expedition.

The 30th Company was formed in 1857 and the 33rd Company in 1858, but they have no war service.

Of the remaining companies, the 22nd, 34th, 35th, 39th, and 40th were all really new companies, though they were given old numbers relinquished by other units at various stages of reorganization. The 48th Company was new both in number and organization.

Details of Companies.

4th Company.

Arrived home from Bermuda, March, 1871. Converted to Submarine Mining Company, April, 1871. 2nd Section to Bermuda and Halifax, and 3rd Section to Portsmouth, May, 1873. Embarked on H.M.S. *Hood*, 18th August, 1873. 3rd Section returned to Chatham, April, 1875. Headquarters at Chatham till October, 1877—practising at Sheerness in 1875, 1876, and 1877. Headquarters and 1st and 3rd Sections to Portsmouth, October, 1877. Detachments to Ceylon and Jamaica, 1878. Headquarters and 1st and 3rd Sections embarked for Bermuda, 18th January, 1882. 3rd Section became 2nd Section, 22nd Company, October, 1884. 2nd Section to Bermuda, September, 1886.

Company to Chatham, November, 1886.
„ „ Harwich, April, 1887.
„ „ Gosport, July, 1887.

Became Central Company for the Submarine Mining School, May, 1892. Converted into a Fortress Company, 1st July, 1905, and remained at Gosport as the company for the Electric Light School.

NAMES OF OFFICERS COMMANDING.

Headquarters.

Capt. G. W. Stockley	April	1871.
Lieut. H. W. Renny-Tailyour	Aug.	1874.
Capt. J. Ramsay	April	1875.
Lieut. F. R. de Wolski	Dec.	1880.
Capt. T. Glancy	July	1881.
Capt. A. C. Alexander	Aug.	1881.
Capt. J. C. Middlemass	June	1885.
Capt. H. E. Rawson	Oct.	1885.
Capt. H. de H. Haig	Sept.	1886.
Lieut. W. S. Vidal	July	1887.
Capt. A. H. Randolph	Jan.	1888.
Capt. W. S. Vidal	July	1891.
Lieut. W. G. Lawrie (Capt. Oct. 1891)	Aug.	1891.
Capt. W. S. Vidal	May	1892.
Capt. W. Baker Brown	Oct.	1894.
Capt. H. N. Dumbleton (Major Aug. 1896)	Aug.	1895.
Capt. C. B. Collins	Feb.	1901.

2nd Section (Bermuda and Halifax).

Lieut. G. Barker	May	1873.
Lieut. H. St. G. Ord	Jan.	1876.
Lieut. C. C. Carter	—	1878.
Lieut. A. E. Wrottesley	April	1882.
Lieut. H. de H. Haig	Dec.	1883.
Lieut. E. C. T. Hawker	June	1885.
Capt. H. de H. Haig	Oct.	1885.

Joined Headquarters, September, 1886.

3rd Section (Portsmouth).

Lieut. R. G. Scott ... ... May 1873 to April 1875.

Joined Headquarters at Chatham, October, 1875.

Detachment (Ceylon).

Lieut. F. Rainsford-Hannay	Aug.	1878.
Lieut. M. A. Cameron	July	1881.

Transferred to 23rd Company, April, 1882.

Detachment (Jamaica).

Lieut. G. A. Tower	Aug.	1878.
Lieut. F. Bowles	July	1881.

Transferred to 23rd Company, April, 1882.

21st Company.

Converted to Submarine Mining Company at Chatham, 1st May, 1885. To Harwich, May, 1888. Converted to Fortress Company, July, 1905.

Names of Officers Commanding.

Capt. C. V. Wingfield-Stratford	May	1885.
Capt. M. D. Whitmore	July	1885.
Capt. E. J. G. Boyce	July	1886.
Capt. P. Von Donop	Nov.	1886.
Lieut. G. L. Fanshawe	Nov.	1888.
Lieut. W. M. Hodder (Capt. June 1889) ...	Mar.	1889.
Capt. A. Grant	Aug.	1889.
Lieut. G. M. W. Macdonogh (Capt. Oct. 1892)	Mar.	1892.
Lieut. G. O. Bigge	Jan.	1896.
Lieut. E. H. Pym	Dec.	1897.
Capt. A. J. Pilcher	Feb.	1897.
Capt. N. G. Von Hugel	July	1899.
Lieut. J. H. Langman	Oct.	1899.
Lieut. M. St. L. Simon	Jan.	1901.
Lieut. E. H. Pym (Capt. Oct. 1902)	April	1901.

22nd Company.

Formed at Harwich as a Submarine Mining Company, October, 1884, from 3rd Section, 33rd Company (Harwich), and 3rd Section, 4th Company (Bermuda).

Headquarters to Chatham, December, 1884.

" " Gravesend for practice, May to September, 1885.

2nd Section joined at Chatham, January, 1886.

To Pembroke Dock, January, 1886.

To Gosport, November, 1886. Practice at Isle of Wight, 1889, 1890.

To Fort Victoria, Isle of Wight, July, 1891.

Converted to Fortress Company, 1st July, 1905.

Names of Officers Commanding.

Headquarters.

Lieut. F. Rainsford-Hannay (Capt. Jan. 1885)	Oct.	1884.
Lieut. O. E. Ruck (Capt. Jan. 1886)	May	1885.
Capt. C. V. Wingfield-Stratford (Major April 1893)	July	1889.
Major J. E. O'H. Hamilton	Sept.	1900.
Capt. D. Brady	Jan.	1903.
Capt. St. G. R. S. Caulfeild	Jan.	1904.
Lieut. A. R. Walker	April	1905.

2nd Section (Bermuda).

Lieut. F. R. Reynolds	Oct. 1884.

Joined Headquarters, January, 1886.

23RD COMPANY.

Converted to Submarine Mining Company at Chatham, April, 1877.

Headquarters to Sheerness, leaving 2nd Section at Chatham, June, 1878.

Headquarters to Portsmouth, November, 1878.

„ „ Chatham, with 1st and 3rd Sections, March, 1879.

Practice at Sheerness, 1879.

Employed as Depôt Company for Submarine Mining at S.M.E. from October, 1879.

Converted to Submarine Mining Depôt Company, 1st April, 1882, and received transfers of the detachments at Hong Kong, Singapore, Ceylon, Mauritius, Jamaica.

Practice at Gosport the summer of 1883 and 1884 with officers' class (rough-water course).

Renamed M Company, April, 1885.

Became a general Depôt Company, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Capt. A. Featherstonhaugh	April	1877.
Lieut. F. de Wolski	April	1878.
Lieut. A. T. Preston	June	1878.
Capt. F. de Wolski	Feb.	1880.
Capt. A. T. Preston	Jan.	1881.
Lieut. M. J. Slater	May	1886.
Major H. C. Fox	July	1886.
Major E. C. Fanshawe	May	1887.
Lieut. H. B. Roberts	Sept.	1887.
Major E. C. Fanshawe	April	1888.
Capt. J. Jervois	July	1888.
Lieut. C. G. Burnaby	Nov.	1889.
Capt. H. B. Roberts	Jan.	1890.
Major W. H. Chippindall	Mar.	1890.
Major W. D. Lindley	Oct.	1892.
Major C. A. Rochfort-Boyd	May	1893.
Capt. B. E. Morony	Aug.	1896.
Major H. J. W. Jerome	Jan.	1897.
Capt. A. H. Van Straubenzee (Major July 1899)	Jan.	1898.
Major H. B. Roberts	July	1901.
Major A. Grant	Nov.	1903.
Major H. E. G. Clayton	April	1905.

For officers with detachments at Hong Kong, etc., see local companies.

27TH COMPANY.

Converted to Submarine Mining Company at Chatham, 1st April, 1882.

Practice at Sheerness, 1883.

2nd Section to Cork, May, 1884.

„ „ Greenock, October, 1884.

„ „ Gosport, November, 1884.

2nd Section became Headquarters and 1st Section, 34th Company, November, 1884. 3rd Section became 2nd Section.

Headquarters and both sections to Chatham, January, 1885.

Headquarters to Devonport, April, 1885. 2nd Section to Cork, rejoined Headquarters, August, 1885.

2nd Section to Bermuda, October, 1885.

Headquarters to Halifax, September, 1886. Divided into two companies, October, 1888, the 27th Company at Bermuda, the 40th Company at Halifax.

Combined with half 36th Company at Bermuda to form 27th (Fortress) Company, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Headquarters.

Lieut. C. C. Carter	April	1882.
Lieut. L. B. Friend	Nov.	1882.
Lieut. F. V. Jeffreys	Sept.	1883.
Lieut. H. E. Tyler (Capt. Aug. 1885)	Dec.	1883.
Capt. H. E. Rawson	Sept.	1886.
Lieut. H. V. Kent	Oct.	1888.
Lieut. L. J. Dopping-Hepenstal	Jan.	1889.
Capt. G. A. Carr	Mar.	1889.
Lieut. A. G. Bremner	May	1892.
Lieut. C. B. Collins	May	1893.
Capt. R. F. Edwards	Feb.	1895.
Capt. H. B. Roberts (Major Nov. 1897) ...	May	1896.
Capt. H. V. Kent	Jan.	1898.
Lieut. L. F. Blandy	Nov.	1899.
Lieut. W. C. Dumble	Sept.	1900.
Capt. G. C. R. Lawrence	April	1901.
Capt. F. M. Close	April	1904.

2nd Section (Cork, Greenock, Gosport).

Lieut. H. E. Tyler	May	1884.

Converted to Headquarters and Section 34th Company, November, 1884.

2nd Section (old 3rd), (Bermuda and Halifax).

Lieut. A. H. Van Straubenzee	April	1885.
Lieut. J. E. O'H. Hamilton	Oct.	1885.
Lieut. P. Burn-Murdoch	Dec.	1885.

Became 27th Company, October, 1888.

28TH COMPANY.

Converted to Submarine Mining Company at Chatham on return from Ashantee War, 27th March, 1874.

Stationed on H.M.S. *Hood*.

Headquarters to Portsmouth, July, 1876, leaving 3rd Section at Chatham.

3rd Section to Gravesend, January, 1877.

„ „ Portsmouth, July, 1877.

Headquarters and 1st and 2nd Sections to Bermuda, November, 1877.

3rd Section to Cork, February, 1878. Practising at Pembroke with sections of 33rd Company in 1878, 1879, 1880, 1881.

Headquarters and 1st and 2nd Sections returned home to Chatham, April, 1882; moved to Gosport, May, 1882.

3rd Section rejoined Headquarters at Gosport, April, 1882.

2nd „ practice at Pembroke Dock, 1882.

3rd „ „ „ „ „ 1883.

3rd „ to Cork, June, 1884.

3rd „ to Liverpool, October, 1884.

3rd „ became 2nd Section, 34th Company, November, 1884.

Headquarters to Gosport, January, 1885.

„ „ Gravesend, November, 1886.

„ „ Chatham, August, 1887.

„ „ Gravesend for practice, 1888, 1889, 1890.

„ „ „ „ permanent station, February, 1891.

Section to Chatham, September, 1891; rejoined Headquarters, May, 1892.

Company to Malta, December, 1894.

Became 28th (Fortress) Company at Malta, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Headquarters.

Lieut. F. W. Heneage (promoted Capt. Jan. 1875), (died 31st Oct. 1881).	July	1874.
Lieut. C. Penrose	Nov.	1881.
Capt. F. R. de Wolski	Mar.	1882.
Lieut. H. E. Wrottesley (Capt. Aug. 1885) ...	April	1884.
Capt. P. Burn-Murdoch	Oct.	1888.

Capt. E. J. G. Boyce (Major May 1894) ...	Nov. 1891.
Lieut. D. H. Ridout (Capt. Oct. 1894) ...	Sept. 1894.
Capt. T. de la H. Brotherton (Major July 1895)	Dec. 1894.
Capt. E. C. Seaman	May 1898.
Major W. MacAdam	Nov. 1902.
Capt. W. M. Thompson	July 1903.

3rd Section (Cork and Pembroke).

Lieut. R. M. Ruck	July 1876.
Lieut. H. E. Rawson	Jan. 1877.
Lieut. R. M. Ruck	July 1877.
Lieut. F. Bowles	Feb. 1881.
Lieut. V. Caillard	Jan. 1882.
Lieut. C. V. Wingfield-Stratford	Feb. 1882.
Lieut. B. B. Russell	May 1883.
Lieut. F. Bowles	Oct. 1883.

Converted to 2nd Section, 34th Company, November, 1884.

2nd Section (Pembroke).

Major E. Druitt ... ... May to Nov. 1882.

Section (Chatham).

Lieut. J. de C. Laffan ... ... Sept. 1891 to May 1892.

30TH COMPANY.

Converted to Submarine Mining Company on arrival from Bermuda, 1st April, 1886.

To Pembroke Dock, June, 1886.

To Plymouth, November, 1886.

Became Central Company for the Submarine Mining School, May, 1892.

Became Fortress Company and remained at Plymouth as company for Electric Light School, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Lieut. A. H. Van Straubenzee	April 1886.
Lieut. L. Jones	Sept. 1886.
Capt. H. E. Tyler	Jan. 1887.
Lieut. W. S. Vidal (Capt. April 1889)	Feb. 1889.
Capt. M. A. Boyd	Mar. 1890.
Capt. F. L. Lloyd	May 1897.
Capt. E. H. Haig	Feb. 1900.
Capt. St. G. R. S. Caufeild	April 1905.

33RD COMPANY.

Converted to a Submarine Mining Company at Chatham in July, 1873.

Embarked on *Hood*, 18th August, 1873.

2nd Section to Malta, November, 1873.

Headquarters to Portsmouth, April, 1875.

3rd Section to Malta, May, 1876.

2nd Section, Malta to Cork, July, 1876.

Headquarters to Devonport, July, 1876. Practice at Pembroke, 1878 to 1879.

2nd Section, Cork to Devonport, April, 1877.

Detachments to Hong Kong, Singapore, and Mauritius, 1878.

Headquarters to Malta, 16th September, 1880.

3rd Section to Devonport, February, 1881. Practice at Pembroke, 1881, 1882, 1883.

3rd Section to Harwich, May, 1884.

3rd Section converted to Headquarters, 22nd Company, October, 1884.

2nd Section to Hong Kong, April, 1885.

Headquarters to Cork, June, 1885, to Gosport, February, 1886.

2nd Section to Chatham, April, 1887; rejoined Headquarters, May, 1887.

Company to Cork, May, 1888.

Practice at Pembroke Dock, June, 1890.

Converted to Fortress Company, absorbing *personnel* of 6th Company, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Headquarters.

Capt. A. Parnell	July	1873.
Lieut. D. O'Brien	Nov.	1873.
Capt. G. M. Collings	July	1874.
Capt. T. H. Anstey	July	1877.
Lieut. W. F. Hawkins	Mar.	1879.
Capt. T. H. Anstey		1880.
Lieut. G. F. Leverson (Capt. 2nd Feb. 1887)...	July	1886.
Lieut. E. Druitt	Jan.	1888.
Capt. H. A. L. Paterson	May	1888.
Capt. W. M. Hodder	Feb.	1891.
Capt. L. J. Dopping-Hepenstal	Sept.	1894.
Capt. N. G. Von Hugel...	May	1895.
Capt. W. L. Palmer	July	1899.
Lieut. M. B. H. O'Donel (Capt. Oct. 1901) ...	April	1901.
Capt. B. W. B. Bowdler	April	1904.

2nd Section (Malta and Cork).

Lieut. M. D. Whitmore... ... ... Nov. 1873.

Rejoined Headquarters, April, 1877.

3rd Section (Malta).

Lieut. G. W. Addison ... ... May 1876.
Lieut. H. P. Knight ... ... 1878.

Joined by Headquarters at Malta, September, 1880.
To Devonport, February, 1881.

Lieut. P. Burn-Murdoch ... ... Feb. 1881.
Lieut. F. Rainsford-Hannay ... ... April 1882.

Converted to 22nd Company, October, 1884.

Detachment (Hong Kong).

Lieut. L. B. Friend ... ... June 1878.
Lieut. O. E. Ruck ... ... July 1881.

Transferred 23rd Company, April, 1882.

Detachment (Singapore).

Lieut. E. H. Rhodes ... ... June 1878.
Lieut. R. S. Hedley ... ... July 1881.

Transferred 23rd Company, 1st April, 1882.

Detachment (Mauritius).

Lieut. H. de H. Haig ... ... July 1878.
Lieut. E. J. G. Boyce ... ... Nov. 1880.

Transferred 23rd Company, 1st April, 1882.

2nd Section (Hong Kong).

Lieut. J. E. Edmonds ... ... April 1885.
Lieut. D. A. Mills ... ... Sept. 1886.

Joined Headquarters, May, 1887.

34TH COMPANY.

Formed at Gosport as a Submarine Mining Company, November, 1884, from 2nd Section, 27th Company, and 3rd Section, 28th Company.

Detachment to Newcastle, November, 1884, to February, 1885.
Headquarters to Malta, April, 1885.
Company to Gravesend, December, 1894.
Became Fortress Company at Gravesend, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Capt. H. E. Rawson	Nov.	1884.
Lieut. L. Quill	Oct.	1885.
Capt. J. C. Middlemass...	Feb.	1886.
Lieut. W. MacAdam	April	1891.
Capt. T. de la H. Brotherton	May	1893.
Capt. D. H. Ridout	Dec.	1894.
Capt. E. C. Seaman	July	1897.
Lieut G. C. R. Lawrence (Capt. Feb. 1899) ...	May	1898.
Capt. H. W. Kelsall	Oct.	1899.
Lieut. B. S. Philpotts (Capt. April 1904) ...	Mar.	1903.

35TH COMPANY.

New Company formed at Chatham, May, 1886.
To Sheerness, January, 1887.
To Pembroke Dock, September, 1887.
Became Experimental Company, May, 1892.
Became Fortress Company, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Capt. G. A. Tower	May	1886.
Lieut. M. J. Slater (Capt. Aug. 1886)... ...	July	1886.
Capt. H. de H. Haig	May	1889.
Capt. F. V. Jeffreys	Nov.	1890.
Capt. P. Burn-Murdoch (Major Sept. 1896) ...	Nov.	1891.
Capt. G. le B. Simmons...	Jan.	1897.
Capt. W. M. Pyne	June	1902.
Capt. R. F. A. Butterworth	Nov.	1904.

39TH COMPANY.

New Company formed at Chatham, May, 1888.
Practice at Sheerness, 1889 and 1890.
To Sheerness, November, 1890.
Became Company for Brennan School, 1st April, 1901.
Became Fortress Company, 1st July, 1905.

NAMES OF OFFICERS COMMANDING.

Lieut. E. Druitt (Capt. Aug. 1888)	May	1888.
Capt. D. A. Mills	April	1889.
Lieut. F. P. Rundle	Nov.	1893.
Capt. G. Le Breton Simmons	May	1894.
Capt. R. F. Edwards	Jan.	1897.
Capt. E. G. Young	Oct.	1897.
Capt. G. C. R. Lawrence	Oct.	1899.
Capt. W. L. Palmer	April	1901.

40th Company.

Formed at Halifax out of 27th Company, October, 1888.

Company brought home on withdrawal of Imperial Garrison from Canada, and disbanded at Chatham, January, 1906.

Names of Officers Commanding.

Capt. H. E. Rawson	Oct.	1888.
Capt. L. J. Dopping-Hepenstal	Jan.	1890.
Capt. D. A. Mills	Nov.	1893.
Capt. H. V. Kent	Dec.	1895.
Major H. B. Roberts	Jan.	1898.
Lieut. R. M. Macrory	July	1901.
Major D. A. Mills	Jan.	1903.
Capt. L. F. Blandy	Sept.	1904.

48th Company.

Formed at Chatham, February, 1900.

To Esquimault, May, 1900.

Broken up on transfer of Canadian Defences to Colonial Government, July, 1906.

Names of Officers Commanding.

Capt. C. S. Cartwright	Feb.	1900.
Capt. (local) B. W. B. Bowdler	May	1900.
Capt. D. Brady	Jan.	1904.

Coast Battalion.

The Coast Battalion was formed in 1885. It consisted of a body of officers recruited from the warrant and non-commissioned ranks of the Royal Engineers, and a body of N.C.O.'s and men of the Royal Engineers, who retained their regimental position and seniority, and were interchangeable with the rest of the Royal Engineer Submarine Miners. There was however at first a very high percentage allowed to be married with leave, the object being to attract the older soldiers and make them settle down at the Coast Battalion stations.

The Battalion was divided into sections, one at each commercial port defended by submarine mines. The duties of the section were the custody and maintenance of the submarine mining defence and the instruction of the Volunteer Submarine Miners at the port. At first the Volunteers were raised as companies of existing corps, but later, when they were formed into separate divisions, the officer of the

Coast Battalion acted as Adjutant of the Volunteer Division in addition to his duties as officer commanding the section.

On 1st July, 1905 the Coast Battalion sections were given a company organization.

The Sections in Scotland, at Forth, Clyde, and Tay, became the 49th (Fortress) Company.

The Sections in the north, at the Tyne, Tees, Humber, and Mersey, became the 16th (Fortress) Company.

The Section at Falmouth became the 18th Company.

The Section at Weymouth became the 6th Company.

The Section at Berehaven became part of the 33rd Company.

The Section at Cardiff was broken up.

New Sections were formed at Lough Swilly (part of the 33rd Company), Guernsey, and Alderney.

Names of Officers.*	Stations.
F. Pring (Qr.-Mr. 13th June 1885, Lieut. 7th Mar. 1886. Retd. 9th Sept. 1896).	Newcastle-on-Tyne.
F. Attwood (Lieut. 13th June 1885, Capt. 19th Oct. 1887. Retd. 4th May 1892).	Liverpool.
W. Lawson (Lieut. 13th June 1885. Died 7th Mar. 1886).	
J. E. Kilby (Lieut. 13th June 1885. Retd. 20th July 1890).	Cardiff. To Portsmouth, 1887. Retd. through ill-health.
A. Michie (Lieut. 13th June 1885, Capt. 15th Feb. 1890. Died 1893).	Office of I.S.D., War Office.
A. Andrews (Hon. Capt.) (Major 1st April 1886. Retd. 12th Sept. 1888).	War Office.
T. Davis (Lieut. 2nd June 1886, Capt. 1st April 1893, Major 1st April 1899).	Greenock.
W. Coyle (Lieut. 2nd Mar. 1887, Capt. 26th Nov. 1893. Retd. 15th Sept. 1897. Retired to take charge of S.M. Defence of New Zealand).	Dundee.
J. London (Lieut. 2nd April 1887, Capt. 1st April 1894, Major 1st April 1899. Died 13th Jan. 1903).	Hull. Liverpool, 1892.
J. Whalley (Qr.-Mr. 2nd Mar. 1887, Lieut. 1st Feb. 1888. Died 16th Feb. 1892).	Cardiff. Dublin, 1889.

* Dates and names are only given up to 1st July, 1905.

Names of Officers.*	Stations.
J. Organ (Lieut. 8th Feb. 1888, Capt. 1st April 1894, Major 13th Jan. 1903).	Leith.
M. Roberts (Lieut. 8th Feb. 1888. Cashiered 1892).	Middlesbrough.
W. Montgomery (Lieut. 7th July 1888, Capt. 1st April 1896).	Falmouth. Woolwich, 1893. Tay, 1896.
W. G. C. Brown (Lieut. 25th Aug. 1888, Capt. 1st April 1896, Major 1st April 1903).	War Office.
W. R. G. Giddy (Lieut. 8th May 1889, Capt. 15th Sept. 1897).	Cardiff.
J. Martin (Lieut. 18th Jan. 1890, Capt. 18th Jan. 1899).	Newcastle-on-Tyne.
B. Sugg (Lieut. 19th Nov. 1890, Capt. 19th Nov. 1899).	Falmouth.
A. Brissenden (Lieut. 1st July, 1891, Capt. 1st July 1900).	Middlesbrough.
J. H. Bailey (Qr.-Mr. 1st July 1891, Lieut. 13th Dec. 1893, Capt. 1st July 1900).	I.S.D.'s Office, 1894.
G. Robins (Lieut. 20th Aug. 1892, Half-pay 3rd Oct. 1895).	Dublin.
C. Ealden (Lieut. 15th Nov. 1893, Capt. 15th Nov. 1902).	Paull-on-Humber. Leith, 1896. Paull-on-Humber, 1897.
G. Etherington (Lieut. 25th Jan. 1896, Capt. 25th Jan. 1905).	Paull-on-Humber. Woolwich, 1897. Berehaven, 1900. Liverpool, 1903.
J. Ruse (Lieut. 22nd April 1896, Capt. 22nd April 1905).	Weymouth.
W. Bolton (Lieut. 29th Sept. 1897)...	Greenock.
G. A. Brown (Lieut. 20th April 1901)	Greenock.
E. A. Flitcroft (Lieut. 20th April 1901).	Cork.
R. Shearburn (Lieut. 20th April 1901)	Leith.
H. E. Burton (Lieut. 4th June 1902)	Tyne.
J. Collins (Lieut. 13th Jan. 1903) ...	Weymouth.

* Dates and names are only given up to 1st July, 1905.

Local Companies Abroad.

At five foreign stations—Hong Kong, Singapore, Ceylon, Mauritius, Jamaica—local units were formed which eventually developed on a composite basis, part being composed of trained Royal Engineers, interchangeable individually with all other trained Submarine Miners, and partly of locally enlisted natives. The officers were always officers of the Royal Engineers.

The commencement of these units was made in 1878, when detachments of an officer and a few men were sent out to each station during a war scare.

These detachments were held on the strength of various home companies, and appear to have counted against their establishment. They were quite inadequate to do more than keep the stores in fair order, and were supplemented by natives engaged as civilians, but employed more or less continuously throughout the year.

In 1882, when the 23rd Company became the Depôt Company for the Submarine Miners, all these detachments were transferred to that company, and provision for them was made in the company establishment.

In 1886 and 1887 separate companies were formed at each of the five ports, and the companies at the four Eastern ports were formed into one organization under the title of the Malay or Eastern Battalion. The European detachments became the nucleus of the various companies.

It was intended at first to enlist all the natives for the whole four stations at Singapore, where the detachments from Hong Kong and Ceylon had assembled for annual practice for several years. The Malay civilians had also proved very capable submarine miners on the water. But when it came to enlist them for a term of years, it was found most difficult to persuade them even to enlist for local service, and all idea of employing them at other stations had to be abandoned. It was thus necessary to enlist the natives locally at each port, and this led to the abandonment of the Eastern Battalion in 1890. The Staff of the Battalion, which was formed on 11th November, 1886, was:—

Major M. D. Whitmore, Commandant, stationed at Singapore.

Major (local) H. P. Knight, 2nd Commandant, stationed at Hong Kong.

Capt. (local) W. G. Shellabear, Adjutant,	Stationed at Singapore.
Hon. Lieut. J. Bull, Quartermaster,	
Sergt.-Major J. Organ,	

The names of the company officers are given under the various stations.

At Jamaica the local company grew as an individual unit, without any attempt at a battalion organization.

Hong Kong Company.

Detachment of 33rd Company embarked for Hong Kong, June, 1878.
Transferred to 23rd Company, April, 1882.
23rd Company became M Company, April, 1885.
Formed into a separate unit as the Hong Kong Company of Eastern Battalion, 1887.
First natives (Chinese) enlisted, 1891.
Company became 40th Company, 1905, retaining the native contingent.

OFFICERS COMMANDING

Detachment (33rd Company).

Lieut. L. B. Friend	June	1878.
Lieut. O. E. Ruck	July	1881.

Detachment (23rd Company).

Lieut. D. A. Mills	Dec.	1883.
Lieut. J. E. Edmonds	Sept.	1886.

Eastern Battalion.

Capt. (local) G. M. W. Macdonogh	April	1888.

Local Company.

Capt. H. N. Dumbleton	Feb.	1891.
Capt. A. E. Wrottesley (Major May 1894) ...	Jan.	1894.
Capt. C. F. Mould (Major April 1900) ...	Nov.	1896.
Major W. Baker Brown...	April	1901.
Major A. C. Painter	Jan.	1904.

Singapore Company.

Detachment of 33rd Company embarked for Singapore, June, 1878.
Transferred to 23rd Company, April, 1882.
23rd Company became M. Company, April, 1885.
Formed into a separate unit as the Singapore Company of Eastern Battalion, 1887.
First natives (Malays) enlisted, 1887.
Company amalgamated with the 41st Company, 1905.
Native portion disbanded, 1905.

OFFICERS COMMANDING

Detachment (33rd Company).

Lieut E. H. Rhodes	June	1878.
Lieut. R. S. Hedley	July	1881.

Detachment (23rd Company).

Lieut. M. A. Cameron	April 1883.
Lieut. E. Druitt	Dec. 1883.
Capt. (local) W. G. Shellabear	Jan. 1887.
Capt. (local) D. H. Ridout	Jan. 1890.

Local Company.

Capt. W. F. Hawkins (Major Dec. 1894) ...	Dec. 1892.
Major H. P. Knight	Dec. 1895.
Lieut. A. J. Woodroffe	Oct. 1897.
Capt. L. Jones	April 1898.
Capt. S. Mildred	Nov. 1901.
Capt. W. M. Pyne	Nov. 1904.

Ceylon Company.

Detachment of 4th Company embarked for Ceylon, August, 1878.

Tranferred to 23rd Company, April, 1882.

23rd Company became M Company, April, 1885.

Formed into a separate unit as the Ceylon Company of Eastern Battalion, 1887.

First natives enlisted (mixed classes), 1887.

Company disbanded on abandonment of Trincomalee, 1905.

OFFICERS COMMANDING.

Detachment (4th Company).

Lieut. F. Rainsford-Hannay	Aug. 1878.
Lieut. M. A. Cameron	July 1881.

Detachment (23rd Company).

Lieut. R. S. Hedley (drowned 1884)	May 1883.
Lieut. F. V. Jeffreys (local Capt. 1887) ...	Oct. 1884.

Eastern Battalion.

Capt. (local) L. Jones	Jan. 1888.

Local Company.

Capt. H. A. L. Paterson	April 1891.
Major E. J. G. Boyce	Dec. 1894.
Lieut. P. B. Molesworth (Capt. July 1896, Major May 1904).	Jan. 1896 to July 1905.

MAURITIUS COMPANY.

Detachment of 33rd Company embarked for Mauritius, July, 1878.
Transferred to 23rd Company, April, 1882.
23rd Company became M Company, April, 1885.
Formed into a separate unit as the Mauritius Company of the Eastern Battalion, 1887.
First natives enlisted (mixed classes), 1887.
Natives disbanded, 1896.
Company amalgamated with 43rd Company, 1905.

OFFICERS COMMANDING.

Detachment (33rd Company).

Lieut. H. de H. Haig ... ... July 1878.
Lieut. E. J. G. Boyce ... ... Nov. 1880.

Detachment (23rd Company).

Lieut. W. M. Hodder (local Capt. 1887) ... Oct. 1885.

Eastern Battalion.

Capt. (local) W. Baker Brown... ... ... Jan. 1889.

Local Company.

Lieut. W. S. Speranza ... ... Mar. 1892.
Lieut. R. T. Dixon (Capt. June 1894)... ... April 1893.
Capt. E. A. T. Tudor ... ... June 1895.
Lieut. E. H. Pym ... ... May 1898.
Lieut. F. W. Robertson... ... ... Feb. 1901.
Lieut. T. T. Grove ... ... June 1902.
Lieut. J. A. Langman ... ... Dec. 1904.

JAMAICA COMPANY.

Detachment of 4th Company embarked for Jamaica, August, 1878.
Transferred to 23rd Company, April, 1882.
23rd Company became M Company, April, 1885.
Formed into a separate Company, 1889.
Natives enlisted, 1889.
Amalgamated with 44th Company, 1905.
Natives disbanded, 1905.

OFFICERS COMMANDING.

Detachment (4th Company).

Lieut. G. A. Tower ... ... Aug. 1878.
Lieut. F. G. Bowles ... ... July 1881.

Detachment (23rd Company).

Lieut. H. A. L. Paterson	Jan.	1883.
Lieut. H. B. Roberts		1885.
Lieut. W. G. Lawrie		1887.
Lieut. J. N. C. Kennedy	Jan.	1889.

Local Company.

Capt. (local) W. P. Brett	April	1889.
Capt. (local) G. L. Fanshawe	June	1891.
Lieut. Clifford Coffin	Aug.	1893.
Capt. (local) W. L. Palmer	Feb.	1894.
Capt. (local) S. L. Owen	Feb.	1896.
Capt. J. E. Edmonds	Feb.	1898.
Lieut. L. F. Blandy	Feb.	1900.
Capt. St. G. R. S. Caulfeild	Jan.	1901.
Lieut. W. Macfie (Capt. April 1904)	Jan.	1903.
Capt. A. D. Carden	April	1905.

CHAPTER VIII.

MILITIA.—OFFICERS AND MEN.—DETAILS OF CORPS.

THE Submarine Mining Militia was first raised in 1878 for the purpose of undertaking the water work of submarine mining at the principal ports. It was formed as one corps, with headquarters at Portsmouth. In 1884 this corps was given a company organization, with companies allotted to Portsmouth (2), Plymouth (1), and Thames and Medway (1). In 1888 the battalion organization was abolished, and local Militia Divisions were formed at each of these commands, and, in addition, new divisions were formed at Pembroke Dock, the Severn, and Harwich. Subsequently the Portsmouth Division was split in 1893 into two distinct organizations for Spithead and Needles, and the Chatham Division in 1892 into separate corps for the Thames and Medway.

The Volunteer Corps at the Humber and Falmouth were formed into Militia Divisions in 1891 and 1892.

All the Militia Corps were embodied during the South African War from about April, 1900, to November, 1900. All corps were officially disbanded in April, 1907.

The officers of the Militia at first went through the full course of submarine mining as laid down for Royal Engineer officers, but about 1886 this course was assimilated to that laid down for Volunteers and divided into three parts ; Part I. (lasting 1 month) was the shore work of submarine mining, Part II. (also 1 month) the water work, and Part III. (2 months) the electrical work. Parts I. and II. were obligatory before promotion, but Part III. was optional, though it was taken by the greater part of the officers.

In addition to these courses, 25 per cent. of the total strength of the officers of a division could be attached annually to the local Royal Engineer Company for defence practice for two months, during which period they took their full share of regimental and mining work.

When the Militia was embodied in 1900, many of the officers took over the submarine mining work from the Regular officers, and some also took charge of Royal Engineer Divisions. They thus proved themselves a very real reserve for the Royal Engineers.

The N.C.O.'s and men of the Militia were enlisted almost entirely for water work, and were thus drawn mainly from the boatmen class.

They were at first paid Militia pay according to rank, but in 1893 they were placed under the general Regulations for Engineer pay, and given rates of pay according to their trade proficiency.

The men were clothed and equipped as Engineers, but parade drill was restricted to simple battalion movements.

Recruits had a preliminary drill including musketry, which lasted 77 days, and each division had an annual training of 55 days—the maximum permissible for the Militia.

The establishments varied a good deal with the locality, but were finally about 50 to 70 men to a division with three to five officers.

There were no regular adjutants of Militia Divisions, but one of the subalterns of the Royal Engineer Company at the station held the appointment of acting adjutant, and looked after the clothing and Permanent Staff outside the training period.

From 1892 a special form of Reserve was formed, which had many of the Militia characteristics, and was attached to Militia Divisions. The men composing it were enlisted into the Royal Engineers, and on the same day their service was converted to six years in the Reserve. They did a probationary period of training as civilians prior to enlistment, and 12 days annual training. There were no officers with this force.

The only actual Militia Corps raised abroad was at Malta, where there were special conditions of enlistment and training. The only officer was an adjutant taken from the Submarine Mining Company at the station. Corps were projected, but not formed, at Bermuda and Halifax.

In the following lists the details are brought up as far as possible to April, 1907, when the Militia Corps were disbanded; but the officers were retained for another year, and many of them accepted transfer to the Special Reserve for Engineer duties, which was formed in 1908. The names of officers who served for less than four years are omitted from the lists.

Southern Submarine Mining Militia.

The first corps was raised at Portsmouth on 23rd November, 1878, and called the Portsmouth (Submarine Miners) Militia.

In January, 1879, it was re-named the Hampshire (Submarine Miners) Militia.

On 1st August, 1880, Lieut. H. P. Knight, R.E., was appointed Adjutant, and held the appointment to 31st July, 1887.

The name was changed to Southern Submarine Mining Militia on 1st September, 1884, when the corps was composed of four companies organized in three divisions and allotted to defences as under :—

The Hampshire, 1st and 2nd Companies, for Portsmouth.
The Devonshire, 3rd Company, for Plymouth.
The Kent, 4th Company, at Chatham.

Capt. H. de H. Haig, R.E., was appointed Adjutant on 31st July, 1887.

On the 30th May, 1888, the corps was split into three separate divisions—"Portsmouth," "Plymouth," and "Thames and Medway."

NAMES OF OFFICERS COMMANDING.

R. C. Daubuz (Captain Commandant 23rd Nov. 1878. Retd. 1882).	In Command, 1878 to 1882. Joined from half-pay, R.E.
I. M. Gray (Capt. 21st Nov. 1878, Captain Commandant July 1882, Honorary Major 1878. Retd. 1883).	In Command, 1882 to 1883.
F. J. Webber (Capt. 11th Feb. 1880, Captain Commandant Feb. 1883, Major 1st April 1887. Retd. 1888).	In Command, 1883 to 1888; late 21st Foot.

OTHER OFFICERS.

R. F. Croker (Capt. 23rd Nov. 1878, Honorary Major 1882. Retd. 1882).	
T. E. Aylmer Jones (Lieut. 10th Mar. 1879, Capt. 23rd Aug. 1882).	To Portsmouth Div., 1888.
C. S. Wainman (Lieut. 30th July 1879. Retd. 1884).	
F. A. Larking (Lieut. 24th Mar. 1880, Capt. 25th Feb. 1888).	To Portsmouth Div., 1888.
A. G. C. Schenley (Lieut. 12th Mar. 1881).	To Portsmouth Div., 1888.
E. S. Castle (Lieut. 26th Jan. 1884).	To Portsmouth Div., 1888.
R. P. Pilgrim (Capt. 26th July 1884).	To Plymouth Div., 1888.
C. P. Boyd (Capt. 8th Nov. 1884).	To Thames Div., 1888.
R. D. L. James (Lieut. 27th Jan. 1885).	To Plymouth Div., 1888.
A. G. Alexander (Lieut. 4th Dec. 1886).	To Plymouth Div., 1888.
L. N. Barrow (Lieut. 28th Jan. 1888).	To Portsmouth Div., 1888.

(1). Portsmouth Militia Division (Submarine Miners).

Formed from Portsmouth Companies of Southern Submarine Mining Militia on 30th May, 1888.

Needles Company formed into a separate division in 1893.

Embodied, 14th April, 1900, to 6th November, 1900.

Disbanded, 1st April, 1907.

Headquarters, Fort Monckton, Gosport, to 1892; Fort Blockhouse, Gosport, 1892 to 1907.

NAMES OF OFFICERS COMMANDING.

T. E. Aylmer Jones (Major 25th Feb. 1888, Hon. Lieut.-Colonel 1899. Retd. 1903).	In Command, 1888 to 1903.
W. Hawley (2nd Lieut. 15th Dec. 1888, Lieut. 4th May 1889, Capt. 4th Mar. 1893, Major 7th Mar. 1903).	In Command, 1903 to 1907.

OTHER OFFICERS.

F. A. Larking (Capt. 25th Feb. 1888. Died 1893).	
E. S. Castle (Capt. 12th May 1888. Retd. 1893).	
A. G. C. Schenley (Lieut. 12th Mar. 1881. Retd. 1889).	
L. N. Barrow (2nd Lieut. 28th Jan. 1888, Lieut. 11th May 1889, Capt. 16th Jan. 1892).	To Needles Div., 1893.
A. P. J. Stourton (2nd Lieut. 4th July 1888, Lieut. 8th Mar. 1890. Retd. 1892).	
H. A. F. Musgrave (2nd Lieut. 21st July 1888, Lieut. 8th Mar. 1890. Retd. 1893).	
O. J. Blundell (2nd Lieut. 2nd Nov. 1889, Lieut. 25th Mar. 1893).	To Needles Div., 1893.
A. FitzR. W. H. Somerset-Leeke (Lieut. 8th Mar. 1890, Capt. 8th July 1893).	To Needles Div., 1893.
W. A. Yockney (2nd Lieut. 19th April 1890, Lieut. 25th Mar. 1893. Retd. 1898).	
T. H. Weldon (2nd Lieut. 7th Jan. 1891, Lieut. 8th July 1893. Retd. 1895).	

G. J. Mitton (2nd Lieut. 17th Jan. 1891).	To Needles Div., 1893.
S. L. Mortimer (2nd Lieut. 4th Mar. 1893, Lieut. 11th Mar. 1896, Capt. 9th Aug. 1902. Retd. 1903).	Seconded, 1901-02.
H. J. N. de Salis (2nd Lieut. 2nd Mar. 1898, Lieut. 6th May 1901, Capt. 9th Oct. 1904).	Seconded, 1901-07.
H. Fulton (Lieut. 10th May 1901, Capt. 3rd Mar. 1904).	
W. G. Tucker (2nd Lieut. 23rd Nov. 1901, Lieut. 15th Aug. 1903).	
F. R. Hime (2nd Lieut. 19th Mar. 1904).	

(2). NEEDLES MILITIA DIVISION (SUBMARINE MINERS).

Formed from Needles Company of Portsmouth Division, August, 1893.

Embodied, 14th April, 1900, to 13th October, 1900.

Disbanded, 1st April, 1907.

Headquarters, Fort Victoria, Isle of Wight.

NAMES OF OFFICERS COMMANDING.

L. N. Barrow (Major 19th Aug. 1893. Retd. 1903).	In Command, 1893 to 1903.
A. FitzR. W. H. Somerset-Leeke (Capt. 8th July 1893, Major 26th Sept. 1903, Hon. Lieut.-Colonel 1903).	In Command, 1903 to 1907.

OTHER OFFICERS.

O. J. Blundell (Lieut. 25th Mar. 1893. Retd. 1903).	
G. J. Mitton (2nd Lieut. 17th Jan. 1891, Lieut. 28th Nov. 1894. Retd. 1897).	
S. Langton (2nd Lieut. 3rd Mar. 1897. Retd. 1900).	
C. H. Guinness (2nd Lieut. 21st Sept. 1900, Lieut. 5th Aug. 1903).	
F. L. Donaldson (Capt. 21st Nov. 1903, Hon. Major 1904).	Late R.G.A. Joined, 1903.
B. M. B. H. Gyll-Murray (Lieut. 6th Feb. 1904).	

(3). Plymouth Militia Division (Submarine Miners).

Formed from Plymouth Company, Southern Submarine Mining Militia, on 30th May, 1888.

Embodied, 14th April, 1900, to 6th November, 1900.

Disbanded, 18th April, 1907.

Headquarters, Elphinstone Barracks, Plymouth.

NAMES OF OFFICERS COMMANDING.

R. P. Pilgrim (Capt. 26th July 1884, Major 4th May 1889, Hon. Lieut.-Colonel 1896. Retd. 1901).	In Command, 1888 to 1901.
R. D. L. James (Lieut. 27th Jan. 1885, Capt. 2nd June 1888, Major 16th Mar. 1901. Retd. 1906).	In Command, 1901 to 1906.
J. H. Prior (Lieut. 20th Feb. 1895, Capt. 8th May 1901).	In Command, 1906 to 1907. Seconded for S.A. War, 1900 to 1905.

OTHER OFFICERS.

A. G. Alexander (Lieut. 4th Dec. 1886. Retd. 1891).	
R. G. Lund (Lieut. 22nd Dec. 1886, Capt. 4th Oct. 1890).	Transferred to Thames Div., 1893.
H. R. Ryder (Lieut. 29th May 1889).	Transferred to Falmouth Div., 1893.
C. A. Riddell (2nd Lieut. 4th Sept. 1889, Lieut. 21st Mar. 1891. Retd. 1895).	
W. E. Bagot (2nd Lieut. 25th Jan. 1890, Lieut. 21st Mar. 1891. Retd. 1894).	
G. P. A. Phillips (2nd Lieut. 18th Feb. 1891, Lieut. 5th Mar. 1894, Capt. 13th Dec. 1899).	To Western Div., 1900.
C. P. Dean (Capt. 10th Jan. 1891, Hon. Major 1895. Retd. 1901).	Joined from Thames Div., 1893.
C. O. Springfield (2nd Lieut. 5th Aug. 1893, Lieut. 19th Sept. 1894. Retd. 1901).	

F. G. Callaghan (2nd Lieut. 8th Aug. 1894, Lieut. 5th Mar. 1897, Capt. 8th May 1901).	
J. F. Rudge (Lieut. 30th Dec. 1899).	From Western Div., 1900.
G. E. Eckford (Lieut. 21st Mar. 1900).	
G. A. Rance (2nd Lieut. 26th Mar. 1902).	
F. W. W. M. Arden (2nd Lieut. 31st Mar. 1906).	

(4). Thames Militia Division (Submarine Miners).

Formed from Kent Companies of Southern Submarine Mining Militia on 30th May, 1888, as the Thames and Medway Division.

Medway Companies formed into a separate division, 1892.

Embodied, 23rd April, 1900, to 6th November, 1900.

Disbanded, 1st April, 1907.

Headquarters at St. Mary's Barracks till 1892. Then at Shornemead Fort, Gravesend.

NAMES OF OFFICERS.

Hon. Lieut.-Colonel.

Lieut.-Colonel C. P. Boyd ... 1904

Commanding.

C. P. Boyd (Capt. 8th Nov. 1884, Major 8th June 1889, Hon. Lieut.-Colonel 1896).	In Command, 1888 to 1904.
C. G. Holland (Capt. 30th Jan. 1894, Major 19th Mar. 1904. Hon. Lieut.-Colonel 1904).	In Command, 1904 to 1907.

Other Officers.

R. C. Wellesley (Capt. 9th June 1888, Major 4th June 1890).	Lieut.-Colonel, Reserve List. To Medway Div., 1892.
E. W. Guinness (2nd Lieut. 16th June 1888, Lieut. 23rd Nov. 1889, Capt. 4th July 1891).	To Medway Div., 1892.
R. M. Lawes (2nd Lieut. 26th Jan. 1889, Lieut. 23rd Nov. 1889, Capt. 4th July, 1891).	To Medway Div., 1892.
T. P. C. Cumming (Lieut. 27th June 1885).	To Milford Haven Div., 1891.

J. M. Chadwick (2nd Lieut. 14th Sept. 1889, Lieut. 4th July 1891. Retd. 1894).	
S. G. Johnson (2nd Lieut. 23rd Nov. 1889).	To Medway Div., 1892.
A. Gibbon-Spilsbury (Capt. 15th April 1885, Hon. Major 1899).	Joined Div., 1890. Resigned, 1898.
C. P. Dean (Capt. 10th Jan. 1891).	Joined, 1891. To Plymouth Div., 1893.
H. Mansford (Lieut. 12th Sept. 1891).	To Medway Div., 1892.
L. N. Blackwell (2nd Lieut. 20th Jan. 1894, Lieut. 27th Feb. 1894, Capt. 15th June 1898).	Seconded, 1895 to 1907.
A. O. Luckman (2nd Lieut. 25th Mar. 1896, Lieut. 9th June 1897, Capt. 15th June 1898).	Seconded, 1897 to 1907.
A. T. Smythe (2nd Lieut. 26th Mar. 1896, Lieut. 9th June 1897, Capt. 15th Feb. 1899).	
T. W. F. Spottiswood (2nd Lieut. 13th April 1896, Lieut. 9th June 1897, Capt. 19th Mar. 1904).	
C. H. Ayscough (2nd Lieut. 28th July 1897, Lieut. 12th July 1899).	Resigned, 1903.
R. H. Muntz (2nd Lieut. 11th April 1900, Lieut. 15th May 1901).	
J. S. Marshall (2nd Lieut. 7th Nov. 1900, Lieut. 13th Feb. 1904).	Resigned, 1905.
G. N. Heathcote (Lieut. 30th July 1904).	
G. A. C. Alcock (Lieut. 18th Feb. 1905).	

(5). Medway Militia Division (Submarine Miners).

Formed from Medway Companies of Thames and Medway Division, April, 1892.

Embodied, 14th April, 1900, to 13th October, 1900.

Disbanded, 1st April, 1907.

Headquarters, Garrison Point Fort, Sheerness.

NAMES OF OFFICERS.

Hon. Lieut.-Colonel.

Lieut.-Colonel R. C. Wellesley...	1898.

Commanding.

R. C. Wellesley (Major 4th June 1890, Lieut.-Colonel, Reserve List).	In Command, 1892 to 1898.
E. W. Guinness (Capt. 4th July 1891, Major 3rd Dec. 1898. Retd. 1904).	In Command, 1898 to 1904.
R. M. Lawes (Capt. 4th July 1891, Major 2nd Dec. 1904).	In Command, 1904 to 1907.

Other Officers.

S. G. Johnson (Lieut. 4th July 1891).	To Falmouth Div., 1893.
H. Mansford (2nd Lieut. 12th Sept. 1891, Lieut. 10th Jan. 1893, Capt. 7th Jan. 1905).	
C. G. Manners-Sutton (2nd Lieut. 6th Mar. 1896, Lieut. 9th Mar. 1898).	Seconded, 1901 to 1903.
A. E. G. Graves (2nd Lieut. 18th Nov. 1893, Lieut. 16th June 1894).	Seconded, 1895. Resigned, 1898.

(6). Harwich Militia Division (Submarine Miners).

Formed, 5th September, 1888.
Embodied, 14th April, 1900, to 6th November, 1900.
Disbanded, 1st April, 1907.
Headquarters, Harwich.

NAMES OF OFFICERS.

Hon. Lieut.-Colonel.

Lieut.-Colonel G. B. Robbins ...	1899.

Commanding.

F. W. Panzera (Capt. 5th Sept. 1888, Major 1st April 1890, Hon. Lieut.-Colonel 1899).	In Command, 1888 to 1893. Seconded for service under Colonial Office, 1893 to 1907.
G. B. Robbins (Major 25th Feb. 1893, Lieut.-Colonel, Reserve List. Retd. 1897).	In Command, 1893 to 1897. Joined from 91st Highlanders, 1893.
F. Gumley (Lieut. 1st Dec. 1889, Capt. 5th July 1890, Major 5th April 1897).	In Command, 1897 to 1901. Died 1901.
E. B. Bartley (Lieut. 21st July 1888, Capt. 5th April 1897, Major 5th June 1901. Hon. Lieut.-Colonel).	In Command, 1901 to 1907. Transferred from Western Div., 1890. Acting Engineer at Harwich, 1901 to 1903.

Other Officers.

B. Johnson (Lieut. 3rd April 1889, Capt. 5th July 1890).	Seconded 1890 for service with Housa Police.
A. F. Bealey (Lieut. 22nd Mar. 1890).	Transferred to Devon and Cornwall Artillery, 1894.
A. R. Willis (2nd Lieut. 25th June 1890, Lieut. 24th May 1893).	Transferred to Western Div., 1897.
P. S. Huth (2nd Lieut. 13th Mar. 1895, Lieut. 2nd Feb. 1897, Capt. 30th Nov. 1901).	
C. E. Lawder (2nd Lieut. 13th Oct. 1897).	Served, South African War. Commissioned, Royal Artillery, 1900.
A. F. Dobbs (2nd Lieut. 16th Nov. 1898, Lieut. 25th Dec. 1901).	
F. C. Grimley (2nd Lieut. 14th Mar. 1900, Lieut. 27th Jan. 1902).	Acting Engineer, Norwich, etc., 1901 to 1904.
C. F. Huth (Lieut. 13th Dec. 1900).	Joined, 1902, from 3rd Gloster Regt.
W. H. Skynner (2nd Lieut. 4th April 1903).	

(7). Milford Haven Division (Submarine Miners).

Formed, 30th May, 1888.
Embodied, 1st May, 1900, to 10th October, 1900.
Disbanded, 1st April, 1907.
Headquarters, Pembroke Dock.

NAMES OF OFFICERS COMMANDING.

H. Davis (Capt. 30th May 1888, Major 12th Nov. 1889. Retd. 1902).	In Command, 1888 to 1902.
E. P. S. Roupell (Lieut. 8th Jan. 1890, Capt. 8th July 1896, Major 14th Mar. 1903. Retd. 1905).	In Command, 1903 to 1905. Seconded, 1894 to 1903.
T. P. C. Cumming (Lieut. 27th June 1885, Capt. 8th July, 1896).	In Command, 1905 to 1907. Joined Div. from Thames and Medway, 1891. Seconded, 1894 to 1896.

OTHER OFFICERS.

P. A. Alexander (2nd Lieut. 15th Dec. 1888, Lieut. 27th July 1889, Capt. 4th Oct. 1890. Retd. 1896).	
H. Curteis (Capt. 24th April 1889)	Joined, 1890. Resigned, 1893.
C. F. Andrew (2nd Lieut. 6th Jan. 1891, Lieut. 27th Jan. 1894).	Resigned, 1903.
D. O. Springfield (2nd Lieut. 7th April 1893, Lieut. 15th May 1896. Retd. 1903).	
R. J. C. Oakes (2nd Lieut. 17th Feb. 1894, Lieut. 26th May 1897).	Seconded, 1901 to 1902. Resigned, 1902.
W. A. C. Mills (2nd Lieut. 14th Oct. 1896).	Seconded, 1899 to 1901. Resigned, 1901.
G. R. F. Fitzgerald (2nd Lieut. 23rd Jan. 1901).	
T. G. H. Studdert (2nd Lieut. 20th Sept. 1902, Lieut. 20th Feb. 1904).	
E. V. Grimshaw (2nd Lieut. 16th Jan. 1904, Lieut. 25th Oct. 1905).	

(8). Western Militia Division (Submarine Miners).

Formed as Severn Division, 30th May, 1888.
Designated South Wales and Severn Division, 1889.
Name changed to Western Division, 1893, Headquarters transferred to Plymouth and Division allotted to Cork Defences.
Trained annually at Fort Camden, Cork Harbour.
Embodied, 14th April, 1900, to 13th October, 1900.
Disbanded, 1st April, 1907.
Headquarters, Pembroke Dock, 1888 to 1893.
 „ Plymouth, Elphinstone Barracks, 1893 to 1904.
 „ „ Mount Wise Barracks, 1904 to 1907.

NAMES OF OFFICERS COMMANDING.

H. C. Reynolds (Capt. 30th May 1888, Lieut.-Colonel, Reserve List (late R.E.)).	In Command, 1888 to 1889.
C. S. Baker (Capt. 21st July 1888, Major 12th Nov. 1889, Hon. Lieut.-Colonel 1897).	In Command, 1889 to 1901.
A. R. Willis (Capt. 22nd Oct. 1897, Major 26th Feb. 1902).	In Command, 1901 to 1907. Transferred from Harwich Div., 1897.

OTHER OFFICERS.

E. B. Bartley (Lieut. 21st July 1888).	To Harwich Div., 1890.
T. P. Murphy (Capt. 10th April 1886. Retd. 1894).	Joined Div., 1889.
A. R. Galsworthy (Lieut. 4th May 1889).	Resigned, 1897.
T. M. Holmes (Capt. 8th Aug. 1888, Hon. Major. Retd. 1899).	Joined, 1889.
G. E. Northey (2nd Lieut. 4th Oct. 1890, Lieut. 18th July 1891).	Resigned, 1896.
S. H. W. Stafford-Jerningham (2nd Lieut. 28th Jan. 1891).	Resigned, 1895.
C. O. Springfield (2nd Lieut. 26th June 1891).	To Plymouth Div., 1893.
R. B. Tonson-Rye (2nd Lieut. 20th Mar. 1892, Lieut. 1st Oct. 1900).	Joined, 1895. Seconded for South African War, 1901 to 1902.
F. S. N. Macrory (2nd Lieut. 12th Feb. 1896, Lieut. 3rd April 1897, Capt. 27th June 1900).	

J. F. Rudge (2nd Lieut. 2nd Dec. 1896, Lieut. 16th Aug. 1899).	
G. P. A. Phillips (Capt. 13th Dec. 1899).	Transferred from Plymouth Div., 1900. Seconded for South African War, 1900 to 1902.
G. M. Ponsonby (2nd Lieut. 30th Aug. 1899, Lieut. 19th Oct. 1901).	Seconded for Service in West Africa, 1900 to 1901. Resigned, 1902.
T. Adams (Lieut. 28th Feb. 1900, Capt. 13th May 1903).	
J. A. Anson (2nd Lieut. 11th July 1900, Lieut. 19th Oct. 1901).	Seconded for South African War, 1901 to 1902.
E. D. D. Jarrad (2nd Lieut. 19th Sept. 1900, Lieut. 19th Oct. 1901).	Resigned, 1905.
H. C. G. Allen (2nd Lieut. 19th Feb. 1902, Lieut. 20th June 1903).	

(9). Humber Militia Division (Submarine Miners).

Formed in lieu of a Volunteer Corps, 2nd November, 1891.
Embodied, 1st May, 1900, to 31st October, 1900.
Disbanded, 1st April, 1907.
Headquarters, Paull-on-Humber.

NAMES OF OFFICERS.

Hon. Lieut.-Colonel.

Sir A. K. Rollit, Knt., 2nd Nov. 1891 (Hon. Lieut.-Colonel 1891).	

Commanding.

W. H. Wellsted (Major 2nd Nov. 1891, Hon. Lieut.-Colonel 1st Jan. 1892. Retd. 1902).	In Command, 1891 to 1902.
C. H. Johnson (Capt. 2nd Nov. 1891, Major 5th Feb. 1902, Hon. Lieut.-Colonel 25th June 1905. Retd. 1905).	In Command, 1902 to 1905.
J. G. Smithson (2nd Lieut. 2nd Sept. 1893, Lieut. 17th July 1895, Capt. 8th June 1896, Hon. Major 1899).	In Command, 1905 to 1907.

Other Officers.

J. Forster (Capt. 2nd Nov. 1891, Hon. Major 20th May 1896).	Resigned, 1896.
C. A. Sebastian Smith (Lieut. 2nd Nov. 1891, Capt. 14th April 1902).	Seconded, 1901 to 1902.
E. W. Major (2nd Lieut. 19th Mar. 1892, Lieut. 1st April 1893).	Transferred, 1900, as Captain to 4th Batt. West Riding Regt.
R. S. Mills (Lieut. 4th Mar. 1896).	Seconded, 1898.
B. C. Barton (2nd Lieut. 19th Jan. 1898, Lieut. 7th Sept. 1900).	Resigned, 1902.
G. A. Ruck (2nd Lieut. 29th April 1899, Lieut. 13th July 1901).	Attached to 5th Batt. Rifle Brigade in South Africa, Dec., 1901, to Oct., 1902. Resigned, 1903.
R. C. Hebden (2nd Lieut. 31st May 1900, Lieut. 30th Aug. 1902).	
G. A. Buttery (2nd Lieut. 28th April 1902, Lieut. 2nd May 1905).	
F. J. Cary (2nd Lieut. 14th May 1904).	

(10). Falmouth Militia Division (Submarine Miners).

Formed in lieu of Volunteer Corps, 2nd November, 1892.
Embodied, 14th April, 1900, to 6th November, 1900.
Disbanded, 1st April, 1907.
Headquarters, Falmouth.

NAMES OF OFFICERS.

Hon. Lieut.-Colonel.

Lieut.-Colonel A. Tremayne ... 1893.

Commanding.

J. Mead (Major 12th Jan. 1893. Retd. 1896).	In Command, 1893 to 1896.
C. H. L. Baskerville (Major 17th Feb. 1897, Hon. Lieut.-Colonel 1900).	In Command, 1897 to 1907.

Other Officers.

J. E. Prower (Capt. 4th April 1893, Hon. Major 1898. Retd. 1905).	Seconded, 1901.
H. R. Ryder (Capt. 5th April 1893).	From Plymouth Div., 1893.
S. G. Johnson (Lieut. 5th April 1893, Capt. 4th Jan. 1896, Hon. Major 1897).	Transferred from Medway Division, 1893. Seconded, 1900.
J. T. D'Arcy Hutton (2nd Lieut. 5th April 1893, Lieut. 2nd Dec. 1893, Capt. 20th June 1900, Hon. Major 1902. Retd. 1903).	
H. C. Fanshawe (2nd Lieut. 28th Oct. 1893, Lieut. 4th Jan. 1896, Capt. 19th Mar. 1901).	
A. P. Wainwright (2nd Lieut. 4th April 1894, Lieut. 25th Mar. 1896, Capt. 27th June 1900, Hon. Major).	
W. G. Vyvyan (2nd Lieut. 12th Feb. 1896, Lieut. 26th May 1897).	Joined Royal Welsh Fusiliers as 2nd Lieut., 1899.
H. P. Matthews (2nd Lieut. 18th Aug. 1899, Lieut. 19th June 1901).	
I. N. N. Watson (2nd Lieut. 18th July 1900, Lieut. 20th May 1903).	Seconded, 1901.
E. C. Bullmore (2nd Lieut. 3rd Feb. 1904).	

CHAPTER IX.

VOLUNTEERS.—OFFICERS AND MEN.—DETAILS OF CORPS.

THE first movement in connection with a Submarine Mining Volunteer Corps appears to be some enquiry at the Tyne by Sir Lintorn Simmons, in 1878, for the formation of a Submarine Mining and Signalling Corps from the Newcastle and Durham Engineer Volunteers, commanded by Lieut.-Colonel Palmer, M.P. In the autumn of 1883 Sir A. Clarke made definite proposals for the formation of a submarine mining company, and a few months later authority was given for a company 120 strong, under Capt. Allison and Lieut. Allan.

The first practice of this company took place in February, 1884, in conjunction with a detachment of Royal Engineers, under Lieuts. Bowles and Quill, R.E.

In October, 1884, similar companies were formed at Greenock from the 1st Lanarkshire Engineer Volunteers, commanded by Colonel Matheson, C.B., and at Liverpool from the 1st Lancashire Engineer Volunteers, commanded by Colonel Rigby, and combined practices were carried out at these stations with sections of the 27th and 28th Companies, commanded by Lieut. H. E. Tyler and Lieut. F. Bowles.

The detailed growth of each corps will be given later.

The regulations for the training and pay of the Submarine Mining Volunteers went through a period of natural growth, and at the date of the abolition of the service the details were as follows :—

Each corps received a capitation grant for each efficient Volunteer —officer or man—at the rate of £5 per head.

Each corps received a camp allowance of 10s. a day for officers and 5s. for men for an annual training of 15 days, and travelling allowances when proceeding to and from camp.

Officers and men attending schools of instruction received pay at the rate of 10s. per officer and 5s. per man.

In addition to this there was a system of whole and half-day parades for technical instruction.

A whole-day parade consisted of not less than six hours' continuous work, and was the equivalent of six drills.

A half day consisted of not less than four hours' continuous work, or four drills.

Pay was given for whole and half-day parades at the rates :—

	Officers.	Men.
Whole day	10s. ...	5s. 0d.
Half day	5s. ...	2s. 6d.

up to a maximum of £10 per individual officer and £5 per individual man, but not exceeding an average of £1 10s. per head for the strength of the corps.

Payment for whole and half-day parades was only granted after a minimum number of 12 voluntary drills had been done by each individual.

The technical training of officers or men consisted of a course of 78 drills and 8 days' camp each year until reported expert, when the compulsory drills were limited to 48 only.

The camp lasted 15 days, of which 8 was compulsory, subject to exemption in special cases. It was the custom in most corps to pay the officers and men during the period of the annual camp out of the amounts received for camp allowance and whole and half-day drills.

The course at the Submarine Mining Schools was divided into three parts. Part I. included the shore work of Submarine Mining, Part II. the water work, and Part III. the electrical work and electric light. Parts I. and II. were compulsory for all officers and carried the letters "p.s." in the *Army List;* Part III. was voluntary and carried the letter (P). All three parts were voluntary for N.C.O.'s and men.

In the event of officers not being able to attend the whole period, they could attend at a school for a fortnight for examination only, and in some cases a local examination was carried out at the stations by an instructor from one of the schools.

The first attendance of officers and men at the schools was in May, 1885, when classes of about 10 officers and 60 men were sent to St. Mary's Barracks for a course of one month.

Although the Volunteer Corps were raised in the first place as companies of existing corps, it was soon found necessary to separate them into distinct units, which was effected about 1888.

The Corps at the Humber and Falmouth were converted into Militia in 1891 and 1892, the conditions of work being more suitable to the Militia form of training.

The Corps of Electrical Engineers was formed in 1897 mainly for electric-light work. Its headquarters were in London, and it was thus not localized.

The capitation grant for this corps was reduced to £4; the annual camp lasted only 8 days (6 days for efficients), and there were no whole and half-day drills. It was thus less well off financially than the Submarine Mining Corps, but gave much less time to training.

The Submarine Mining Volunteers had no permanent staff or Adjutant, but the section of the Coast Battalion serving at the station acted as staff and the officer of the Coast Battalion was Acting Adjutant and Staff Officer to the O.C. Volunteer Unit in addition to his special duties in charge of the submarine mining defence.

The following lists give the names of all officers of the rank of Captain and upward.

The number before each Corps represents the order of precedence of divisions.

The account of the Forth Division has been compiled by Major Cadell, and is inserted as typical of the growth of these corps.

(1). Tyne Volunteer Division (Submarine Miners).

First formed as a company of Newcastle and Durham Engineer Volunteers in 1884.

Formed as a separate unit under the title of Tyne Volunteer Division, Submarine Miners, Royal Engineers, in 1888, under Major Wm. Johnson. Strength increased from three to five companies in 1900, and to seven companies in 1904.

Converted into Electrical Engineers, 1st April, 1907.

This corps, in addition to manning its local defences, formed detachments for mining at Portland, and for electric-light work at the Humber and Portsmouth, and also frequently provided detachments for manœuvres at other places.

Its strength prior to conversion was 30 officers and 427 other ranks.

Its headquarters were at Cliffords Fort, North Shields.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Sir C. W. Palmer ... ... 1888.

Commanding.

W. Johnson, V.D., C.B. (Major 3rd Mar. 1888, Lieut.-Colonel 1st April 1903).	In Command, 1888 to 1907.

Other Officers.

C. Baguley (Capt. 3rd Mar. 1888)	Resigned, 1890.
J. R. Scott (Capt. 20th July 1889).	Resigned, 1896.
F. G. Scott (Capt. 20th July 1889, Major 1st April 1903).	
R. H. Wesencroft (Capt. 4th Oct. 1890).	Resigned, 1896.
C. R. Toomer (Capt. 8th July 1896, Major 4th June 1904).	
R. Stephenson (Capt. 26th July 1896).	Resigned, 1901.
E. Towers (Capt. 11th Aug. 1900).	
A. Blackburn (Capt. 11th Aug. 1900).	
C. Johnson (Capt. 13th July 1901).	
G. A. Bruce (Capt. 13th June 1903).	
E. Robinson (Capt. 13th June 1903).	
G. Towers (Capt. 4th June 1904).	
S. Readhead (Capt. 4th June 1904).	

(2). Severn Volunteer Division (Submarine Miners).

First formed as a company of the 1st Gloucester Engineer Volunteers.

Formed into a separate corps, 1888, as the Severn Volunteer Division, Submarine Miners, R.E. Strength increased from three to four companies, 1900.

Converted into Electrical Engineers, 1907.

In addition to the defences of Cardiff, this corps provided a detachment to man the Electric Lights at Pembroke Dock.

Its strength before conversion was 16 officers, 243 other ranks.

The headquarters were at Cardiff.

Names of Field Officers and Captains.

Hon. Lieut.-Colonel Commandant.

Major-General H. H. Lee (Retd. R.E.).	1888 to 1904.

Commanding.

A. Thornley, V.D. (Major 28th May 1887. Retd. 1898).	In Command, 1888 to 1898.
J. H. Hughes (Capt. 29th July 1893, Major 16th Mar. 1898, Lieut.-Colonel 13th May 1903. Retd. 1903).	In Command, 1898 to 1903.
W. H. D. Caple (Capt. 3rd Feb. 1898, Major 13th May 1903).	In Command, 1903 to 1907.

Other Officers.

G. F. Lynch Blosse (Capt. 27th June 1888).	Resigned, 1893.
F. G. Olliver (late R.N.) (Capt. 23rd Mar. 1889).	Resigned, 1892.
E. C. Lyne (Capt. 1st April 1889)	Resigned, 1891.
H. Webb (Capt. 5th Aug. 1891)	Resigned, 1893.
G. D. A. Thornley (Capt. 23rd July 1892).	Resigned, 1898.
H. T. Thornley (Capt. 16th June 1894).	Resigned, 1898.
G. Hooper (Capt. 6th April 1898)	Resigned, 1907.
A. O. Evans (Capt. 2nd July 1898).	
T. O. Edwards (Capt. 11th July 1900).	
H. W. Flint (Capt. 9th Mar. 1900).	Resigned, 1902.
G. Hooper (Capt. 21st Feb. 1903)	Resigned, 1906.

(3). Clyde Volunteer Division (Submarine Miners), Royal Engineers.

First formed as a company of the 1st Lanarkshire Engineer Volunteers under Capt. J. Lang and Capt. D. Campbell.

Formed into a separate unit in 1888 as the Clyde Volunteer Division under Major A. E. Black.

Strength increased from three to four companies, 1900.

Converted into Electrical Engineers, 1907.

Its strength at the time of conversion was 16 officers, 243 other ranks.

Its headquarters were at Fort Matilda, Greenock.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Sir D. Matheson...	1888 to 1901.
Colonel E. D. Malcolm, C.B. (Retd. R.E.).	1901.

Commanding.

A. E. Black (Major 1st Feb. 1888. Retd. 1893).	In Command, 1888 to 1893.
W. W. B. Rodger (Capt. 25th Feb. 1888, Major 11th July 1894. Retd. 1897).	In Command, 1894 to 1897.
D. F. W. Neill (Capt. 8th Feb. 1890, Major 22nd Dec. 1897, Lieut.-Colonel 1st April 1903).	In Command, 1897 to 1907.

Other Officers.

A. R. Miller (Capt. 12th Jan. 1889).	Resigned, 1897.
H. B. Collins (Capt. 4th May 1895).	Resigned, 1901.
N. Macleod (Capt. 9th Dec. 1896).	Resigned, 1902.
R. C. Cochran (Capt. 19th Jan. 1898).	Resigned, 1902.
D. B. Anderson (Capt. 30th May 1900, Major 1st April 1903).	
A. H. Anderson (Capt. 21st Sept. 1901).	
J. D. Murdoch (Capt. 6th Jan. 1904).	
A. M. Connell (Capt. 8th Oct. 1904).	

(4). Humber Volunteer Division (Submarine Miners).

Formed at Hull in 1888 by Sir A. Rollit, M.P., for defence of the Humber.

Converted into Militia, 1891.

Headquarters, Paull-on-Humber.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Sir A. K. Rollit, Knt. ... ... 1888 to 1891.

Commanding.

W. H. Wellsted (Major 3rd Mar. 1888). In Command, 1888 to 1891.

Other Officers.

C. H. Johnson (Capt. 30th July 1887).

J. Forster (Capt. 2nd May 1888).

All these officers transferred to the Militia Division.

(5). Tees Volunteer Division (Submarine Miners).

Formed in 1888 at Middlesbrough for the defence of the Tees. Training at South Gare.

Converted into Electrical Engineers, 1907.

Its establishment at date of conversion was 10 officers and 123 other ranks.

Its headquarters were at Middlesbrough.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Lieut.-Colonel Commandant.

Lieut.-Colonel J. T. Belk ... 1898 to 1907.

Commanding.

J. T. Belk (Major 3rd Mar. 1888. Retd. 1898). In Command, 1888 to 1898.

T. Belk (Capt. 26th July 1890, Major 25th May 1898). In Command, 1898 to 1907.

Other Officers.

T. G. Barlow Manicks (Capt. 15th Feb. 1888). Resigned, 1890.

W. Harkess (Capt. 28th June 1890). Resigned, 1894.

G. Cowper (Capt. 15th June 1898). Resigned, 1904.

H. Winterschladen (Capt. 15th June 1898).

G. Hedley (Capt. 13th Feb. 1904).

(6). Tay Volunteer Division (Submarine Miners).

Formed in 1888 at Dundee for the defence of the Estuary of the Tay.

Strength increased from three to four companies, 1900.

Disbanded, 1907, on withdrawal of mining and light defences from the Tay.

Headquarters, Dundee.

NAMES OF FIELD AND COMPANY OFFICERS.

Hon. Colonel Commandant.

Admiral Maitland Dougall ... 1888.

Commanding.

W. H. Fergusson (Major 17th Mar. 1888, Lieut.-Colonel 1st April 1903. Retd. 1904).	In Command, 1888 to 1904.
F. S. Stephen (Capt. 11th Sept. 1895, Major 1st April 1903, Lieut.-Colonel 28th May 1904).	In Command, 1904 to 1907.

Other Officers.

R. A. Fergusson (Capt. 17th Mar. 1888).	Resigned, 1897.
E. Carmichael (Capt. 25th May 1889).	Resigned, 1896.
J. H. White (Capt. 21st Oct. 1896, Major 28th May 1904).	
J. A. Murdoch (Capt. 2nd June 1897).	
W. M. G. Thomson (Capt. 6th June 1900).	
L. J. Gariock (Capt. 28th May 1904).	

(7). Forth Volunteer Division (Submarine Miners).

The Forth Division was raised in the end of 1887 by Capt. F. Grant Ogilvie, formerly in the Aberdeen Volunteers, with Mr. Theodore Salvesen, of Leith, as First Subaltern, and Lieut. (afterwards Major) James Organ, Coast Battalion, R.E., as Adjutant and Instructor. In the beginning of 1888 three more officers were gazetted as 2nd Lieutenants, viz., Mr. Henry M. Cadell, of Grange, Bo'ness, J.P., Mr. James Currie, jun., shipowner, of Leith, and Prof. T. Hudson Beare, of Edinburgh, while Lord Hopetoun (afterwards Marquis of Linlithgow), a large riparian proprietor on the Forth, showed his good-will by becoming Hon. Colonel. Of these subalterns, only the first, who had served previously for six years in the Queen's

Edinburgh Rifle Volunteer Brigade, remained till the end of submarine mining, and commanded the corps at the Royal Review in 1905.

The first enrolment of recruits took place in May, 1888, when the establishment consisted of three companies, under the command of a major. The first camp was held on Inchkeith, the island fortress in the centre of the Firth of Forth opposite Leith, in a very wet and stormy fortnight in 1888, and for many years the hulk of H.M.S. *Dido*, lent by the Royal Navy, was used as storeship, office, and headquarters, and was moored at the minefield during the training in the Firth, pending the construction of a permanent shore establishment. The *Dido* lay in Leith Docks during the non-training period.

Owing to changes in the scheme of defence it was decided to move the submarine mining establishment some miles further up the estuary, and the training ground of the corps was accordingly transferred, after several years at Inchkeith, to North Queensferry, near the new defence minefield outside the Forth Bridge and naval base of Rosyth.

In 1900 Major Ogilvie was succeeded in the command by Major Theodore Salvesen, who became Lieut.-Colonel when a fourth company was raised during the war, a considerable number of the men having gone to the front on active service that year.

With the prospect of a permanent establishment at North Queensferry, a handsome Officers' Mess was built and other amenities were added, which maintained the popularity of the corps among both rank and file. The corps had the full complement of officers, and the good discipline and excellence of the work done were attested by successive inspecting officers. Among other characteristics, the Forth Division could boast of two corps songs, or rather a *corps* song and an *encore song** the singing of which was a feature at all social functions.

In 1904 Lieut.-Colonel Salvesen was succeeded in the command by Lieut.-Colonel and Hon. Colonel H. M. Cadell, V.D., the oldest Volunteer in the Mess.

The corps was converted into Electrical Engineers, 1907. Its establishment at the date of conversion was 16 officers and 243 other ranks.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Right Hon. Lord Hopetoun ... 1888.

Commanding.

F. G. Ogilvie (Major 31st Mar. 1888. Retd. 1900). In Command, 1888 to 1900.

* See Preface.

T. Salvesen (Capt. 2nd April 1888, Major 12th Dec. 1900, Lieut.-Colonel 1st April 1903. Retd. 1904).	In Command, 1900 to 1904.
H. M. Cadell, V.D. (Capt. 4th May 1889, Major 1st April 1903, Lieut.-Colonel 28th Jan. 1905. Retd. 1906).	In Command, 1905 to 1906.
C. D. Murray (Capt. 20th Sept. 1899, Major 25th Mar. 1905).	In Command, 1906 to 1907.

Other Officers.

T. H. Beare (Capt. 31st Mar. 1888).	Resigned, 1899.
S. Smith (Capt. 6th June 1900).	
A. Ogilvie (Capt. 16th Feb. 1901).	
J. Cowan (Capt. 17th Feb. 1906).	

(8). The Mersey Volunteer Division (Submarine Miners), Royal Engineers.

First formed as K Company of the 1st Lancashire Engineer Volunteers, under Capt. Beloe, with Lieuts. Pilcher and Poulson.

This company assembled for training in 1885 in King's Dock, Liverpool, the men sleeping in hammocks in a shed, the officers in a chartered tug which lay in the dock. Two old hulks, H.M.S. *Danæ* and the *Annetin*, were provided as headquarters in 1886, and moored in King's Dock till 1904, when they were moved to Clarence Dock.

A detachment went to Milford Haven for the manœuvres there in 1886.

In March, 1888, the above company was disbanded, and in June a separate unit was formed, with the title of Mersey Volunteer Division, Submarine Miners, Royal Engineers, under the command of Major R. Montgomery. There were three companies, with an establishment of 13 officers and 183 rank and file.

In 1892 Major A. H. Knight took over the command and commenced a series of annual camps under canvas at New Brighton, and from this time the strength rose till the full establishment was reached in 1902.

The establishment was increased by one company in 1903 to a total of 16 officers and 259 men.

In 1905 Lieut.-Colonel H. Langdon took over command, the strength this year being 12 officers and 238 rank and file.

The division was converted into Electrical Engineers in 1907.

NAMES OF FIELD AND COMPANY OFFICERS.

1st Lancashire Engineer Volunteers.

Capt. C. H. Beloe (joined 1885)	Resigned, 1888.
Capt. T. Eastwood (joined 1885)	Resigned, 1889.
Capt. T. K. Nuttall (joined 1886)	Resigned, 1889.
Capt. J. E. Rayner (joined 1887)	Resigned, 1888.

Mersey Volunteer Division.

Hon. Colonel Commandant.

Sir J. Poole	1888 to 1892.
Major R. Montgomery	1892.

Commanding.

R. Montgomery, V.D. (Major 17th Mar. 1888. Retd. 1892).	In Command, 1888 to 1892.
A. H. Knight, V.D. (Capt. 27th Nov. 1890, Major 18th June 1892, Lieut.-Colonel 13th June 1903. Retd. 1905).	In Command, 1892 to 1905.
H. Langdon, V.D. (Capt. 11th Feb. 1893, Major 1st April 1904, Lieut.-Colonel 25th Feb. 1905. Hon. Colonel).	In Command, 1905 to 1907.

Other Officers.

H. J. Merrick (Capt. 28th Nov. 1890).	Resigned, 1891.
R. G. T. Kelly (Capt. 29th Nov. 1890).	Resigned, 1891.
T. H. Wilkinson (Capt. 21st May 1892).	Resigned, 1896.
J. P. McKenna (Capt. 27th May 1892, Major 13th June 1903).	Resigned, 1904.
J. W. Lloyd (Capt. 7th April 1897).	Resigned, 1903.
J. H. Jones (Capt. 13th June 1903, Major 22nd April 1905).	
A. H. Jones (Capt. 4th July 1903).	
W. F. Price (Capt. 2nd April 1904).	
T. R. Wilton (Capt. 22nd April 1905).	
Qr.-Mr. H. Archbold (Qr.-Mr. 25th May 1898)	Late Sergt.-Major, R.E. Hon. Captain.

(9). Falmouth Volunteer Division (Submarine Miners).

Formed at Falmouth in 1888.
Converted into Militia, 1892.
Headquarters, Falmouth.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Lieut.-Colonel A. Tremayne ... 1888 to 1892.

Commanding.

J. Mead (Major 2nd Mar. 1889)	In Command, 1888 to 1892. Transferred to Militia.

Other Officers.

A. F. Bealey (Capt. 20th July 1889).	Resigned, 1890.
W. J. Jenill (Capt. 27th July 1889).	Resigned, 1892.

Corps of Electrical Engineers (Royal Engineers), Volunteers.*

In 1895 the Council of the Institution of Electrical Engineers, at the instigation of Dr. John Hopkinson, resolved to offer the services of their profession to the country for its defence. The proposal was warmly supported by Lieut.-General Sir R. Grant, I.G.F., who directed Major R. M. Ruck, I.S.D., to draw up provisional conditions of service, with Dr. John Hopkinson's assistance.

John Hopkinson, D.Sc., F.R.S., the President of the Institution, was gazetted Major in 1897, to form and command the corps.

An Adjutant, Lieut. D. Brady, R.E., was appointed on the 1st of June, 1897, and during the next few weeks the following officers were gazetted :—

Capts. R. E. B. Crompton, A. E. Mavor, R. S. Erskine, and B. Hopkinson ;

Lieuts. A. E. Le Rossignol, H. M. Leaf, W. A. Vignoles, A. Bain, J. J. F. O'Shaughnessy, A. H. Pott ;

and one N.C.O., Q.M.S. (Acting Sergt.-Major) J. Gunn, R.E., was appointed.

No men were enrolled as yet, but during the summer all the officers went for about three weeks to the western end of the Isle of Wight to see something of the work they were to do. The plant they saw was more miscellaneous than modern, but that was not altogether a disadvantage. Meanwhile Lord Kelvin was gazetted Hon. Colonel of the Corps.

* This account was compiled by Capt. D. Brady, R.E.

The Isle of Wight trip was in some ways amusing. Major Wingfield-Stratford gave a short lecture, and Capt. Crompton, long accustomed to the ways of scientific meetings, made an excellent speech in reply, much to the astonishment of Wingfield-Stratford. It was plain that the Military Mechanist Electrician had no awe of Doctors of Science or Fellows of the Royal Society, for Doctor Hopkinson, the most distinguished Engineer in England, not even excepting Lord Kelvin, had many friendly arguments with him, and did not always come off best. Most of the juniors wanted to do junction-box-boat work until they did it—in a rather choppy sea.

After the trip a few men were enrolled, and the work of framing conditions of efficiency began. The conditions for other Volunteers were not suitable, as they required a number of drills impossible to the sort of men required. Thanks principally to Major-General Salmond, R.E., conditions acceptable to the corps and to the War Office as well were found. They required what was then not necessary for other Volunteers (except the Submarine Mining Corps)—a continuous training of from 8 to 10 days at Service work at a Service station. Nearly everything was arranged at a few interviews with the D.A.G., R.E., or the I.S.D., and there was not much correspondence.

The work of starting the corps once done, there was no difficulty in getting men, for none but the best were accepted, and it became rather a distinction to be enrolled.

Fortunately for the corps, it was strong and growing when it suffered the great loss of its chief, Major Hopkinson ; John Hopkinson (his plain name is the only title a man of great distinction retains) was killed in the Alps on the 26th of August, 1898. With him died three of his children, but his eldest son, Major B. Hopkinson, is still a member of the Corps.

Capt. Crompton got his Majority and the command. In 1899, at a small dinner at the Restaurant in 26, Victoria Street, Major Crompton and many other officers decided to offer their services for South Africa, and before the war was over more than 300 Electrical Engineers, Royal Engineers (Volunteers), including every officer who was not positively compelled to stay in England, went out, not to join existing Regular units, but as units themselves, with their own equipment for their own work.

The headquarters of the corps was at first a room in Doctor Hopkinson's Office, 5, Victoria Street. It was moved to a small suite of rooms in 13, Victoria Street, when Doctor Hopkinson's Office became too small for it. Meanwhile the whole country round London was explored in search of a suitable headquarters, and the site of its present headquarters was at last selected, and they were first occupied in the autumn of 1901.

The original members of the corps did the few drills that were found necessary (apart from the training) in many odd places—in the small rooms of 5 and 13, Victoria Street, until the occupiers of neighbouring rooms threatened an injunction; in the tiny courtyards until the same thing happened; in the old Aquarium; on a waste piece of ground behind Victoria Street until the enterprising builder turned them out; and, going this time from the ridiculous to the sublime, in Westminster Hall, by permission of the Speaker and probably of the Lord Chancellor too. In the summer the parade of Wellington Barracks was used by permission of the Brigade of Guards, but it was rather too public for comfort.

The country detachments, and they were many, found drill grounds for themselves, nearly as miscellaneous, but whatever the drill ground might be, they certainly learned their drill.

The erection of the Regency Street Headquarters solved the difficulty.

This corps in 1907 had an establishment of 35 officers and 697 men, and drew its recruits from the Midlands, as well as London and neighbourhood. It had also a student branch recruited at Cambridge.

It found detachments for electric-light work at Portsmouth, Portland, Plymouth, Falmouth, Scilly Isles, Dover, Sheerness, Gravesend, and Harwich.

It became in 1907 the London Division, Electrical Engineers.

NAMES OF FIELD OFFICERS AND CAPTAINS.

Hon. Colonel Commandant.

Lord Kelvin ... ... 1897.

Commanding.

J. Hopkinson (Major 28th April 1897).	In Command, 1897 to 1898. Died 1898.
R. E. B. Crompton, C.B. (Capt. 18th Aug. 1897, Major 7th Dec. 1898, Lieut.-Colonel 11th May 1900).	In Command, 1898 to 1907.

Other Officers.

A. E. Mavor (Capt. 18th Aug. 1897).	Resigned, 1900.
R. S. Erskine (Capt. 18th Aug. 1897, Major 18th April 1900).	Resigned, 1904.
B. Hopkinson (Capt. 25th Aug. 1897, Major 5th Sept. 1903).	
A. E. Le Rossignol (Capt. 13th Jan. 1900).	

A. Bain (Capt. 13th Jan. 1900, Major 4th Nov. 1904).	
H. M. Leaf (Capt. 15th Jan. 1900, Major 5th Nov. 1904).	
W. A. Vignoles (Capt. 20th June 1900).	Resigned, 1904.
J. J. E. O'Shaughnessy (Capt. 20th June 1900).	
A. H. Pott (Capt. 20th June 1900).	Resigned, 1904.
J. H. Shawe (Capt. 14th Dec. 1901).	Resigned, 1902.
J. H. S. Phillips (Capt. 14th Dec. 1901).	
Hon. R. C. Craven (Capt. 14th May 1902).	Resigned, 1904.
J. E. Pearce (Capt. 14th May 1902).	
K. W. E. Edgcumbe (Capt. 14th May 1902).	
H. F. Bigge (Capt. 7th May 1904).	
E. R. Clarke (Capt. 7th May 1904).	
E. H. Leaf (Capt. 5th Nov. 1904).	
G. B. Williams (Capt. 7th Mar. 1905).	

CHAPTER X.

SUBMARINE MINING IN INDIA.*

THE commencement of Submarine Mining in India may be held to date from the 20th February, 1868. A minute of that date by Major-General Sir Henry Durand recommended the appointment of "a Select Committee of Scientific Officers to carry on a series of experiments, so that in case of war we may have an organized system of torpedo defence for our Calcutta and Rangoon rivers." In support of his recommendations, Sir H. Durand stated, "Nothing is more dreaded by troops or seamen than the destructive means of this kind of defence, which science places at the disposal of the attacked; and a hostile squadron, with no dockyards at hand in which to refit, would be careful how it encountered a system of defence which, where it fails to utterly destroy, hardly can fail to injure most dangerously. Moreover it is not a costly means of defence, though so formidable and destructive, if rightly managed."

Consequent on the above recommendation, a special Committee was appointed in April, 1868, under the presidency of Colonel Hyde, R.E., Mint Master at Calcutta, to "consider and report upon torpedo defences and their applicability to the defence of rivers, especially with reference to the proposed defences of the Hughli and the Mutlah."

The preliminary report of the Committee was submitted on 31st August, 1870, and considerable impetus was given to the discussion of the subject by the scare which followed the outbreak of the Franco-German War, when all authorities agreed that the defence of Indian ports should be provided for.

On the 21st July, 1871, a second report of the Committee was submitted, which contained proposals for the defence of the Hughli by torpedoes and booms, at an estimated cost for material only of £35,000; but although this expenditure was apparently agreed to, and the Viceroy (Lord Mayo) "thought it most desirable we should have on hand a large supply of torpedo material," nothing was done. Another progress report was sent in by the Committee on the 15th March, 1875. The Committee had at that date since its commencement spent a sum of Rs.1,23,500 on experiments.

As it appeared to the Military Department that the Committee had

* This account of the growth of the Indian Submarine Mining Service was compiled in 1907 by Major W. P. Brett, I.S.D., in India.

not achieved results commensurate with the expenditure incurred, they proposed the Committee should cease to exist, and that its functions might devolve upon the Garrison Engineer, Fort William, with a special assistant. The Public Works Department noted in reply that nothing had really been done as regards the torpedo defences, and recommended that a specially trained naval or military officer should be got out from England to be responsible for the torpedo defences, take charge of the stores, and train the establishments.

It is desirable here to pass in review the work of the Torpedo Committee. The President and members were all officers of the Royal Engineers employed in the Public Works Department, and had to give such time as they could spare from their proper duties to the work of the Committee. This remark applies even to the Secretary at the commencement. It soon became evident that nothing could be done with this arrangement, and ultimately the services of a Secretary were sanctioned who could give his whole time to the work of the Committee. The Secretary thus became in reality the Executive Officer of the Committee, and was mainly employed in working out details of designs of apparatus, etc.

It was obviously not appreciated at the time that the task set to the Committee was a severe one. They had practically no groundwork to go on, but had to invent and design material *ab initio*, with such skilled assistance as the engineering workshops at Calcutta could afford—at that time not very great. Progress was necessarily slow, but at the end of 1870 the following work was in progress or had been completed :—

(*a*). Examination of the rivers Hughli and Mutlah, with a view to determine the most favourable site for torpedo defence supported by shore batteries.
(*b*). The design of floating obstructions and booms.
(*c*). Self-acting moored torpedoes.
(*d*). Self-acting moored torpedoes fired by electricity from the shore.
(*e*). "Ground" torpedoes fired by double observation from the shore.

All the difficulties so well known to early workers in submarine mining were experienced both as regards mechanical details and electrical arrangements. Very little apparatus and materials were available, and we find the Committee designing and manufacturing Voltaic cells, insulated cable—even fuzes.

The work must have furnished useful experience to the officers engaged, but much of it must have been wasted, inasmuch as a Torpedo Committee in England was engaged at the same time in similar work, and naturally, with much greater resources at their disposal, were able to design workable apparatus and develop an electrical system of submarine mining, better and more complete than was possible by the Indian Committee at Calcutta.

Reverting to the narrative of events, the Secretary of State was asked, consequent on the recommendation of the P.W.D., to send out an officer who should be " responsible for the torpedo defences of the ports and harbours of India, and who *should confine himself to the preparation of projects, and to the observation of the deterioration or damage of materials by the climate.*

The Secretary of State approved, subject to certain conditions, and Capt. Collings, R.E., was sent to India on 1st June, 1877, for the above duty, and gazetted as an Assistant Adjutant-General. The selection was unfortunate, as Capt. Collings almost immediately lost his health. In June, 1878, Capt. Featherstonhaugh, R.E., was sent out in his place, and gazetted Assistant Adjutant-General.

Capt. Featherstonhaugh's task was not an easy one. He had to devise schemes for submarine mining defence for the various ports at which land defences were almost non-existent. He had to obtain the necessary stores, of which the only supply in India was the experimental material handed over by the Torpedo Committee. He had to devise schemes for obtaining *personnel* and training them.

On the part of the Government, periods of lassitude were succeeded by periods of energy (as far as the development of submarine mining was concerned) under the influence of war scares. The war scare of 1878 resulted in Government deciding on systems of 12 mines at each of the following places:—The Hughli, Rangoon River, and Karachi Harbour. It was thought unnecessary to provide for Aden, and that at Madras and Bombay any effective operations would have been on too large a scale for the powers of an untrained establishment. Fortunately the India Office had ordered stores for 170 mines, and although the Government of India telegraphed to countermand all in excess of 36 mines, the countermand arrived too late.

It was in this somewhat accidental manner that at last a fair equipment of stores was obtained, and for the next few years the chief difficulties met with were in connection with the provision and training of the *personnel.*

In 1879 a beginning was made with the *personnel* by training some officers and men of the Sappers and Miners, but these disappeared on the outbreak of the Afghan War, and for the next few years nothing was done.

It is curious to note at this period what a lack of appreciation existed concerning the work of a submarine miner. It appears to have been thought that an efficient *personnel* could be obtained by putting a number of N.C.O.'s and men through a "course" of submarine mining, and then allowing them to return to their ordinary duties, so that in time a considerable number would be trained. It was natural at first that the new duty should be attached to an existing organization, viz., the Corps of Sappers and Miners, but it was soon recognized that some specially trained men were necessary as a permanent establishment; consequently a *personnel* as follows was authorized in 1883 for the ports named, on the strength of Sappers and Miners:—

	Officers.	Store-holders.	Royal Engineers.	Lascars.
Bombay	1	1	8	10
Calcutta	1	1	8	10
Karachi	1	1	8	10
Rangoon	1	1	8	10

For practice and war purposes it was the intention to supplement the above permanent detachments by native sappers who had been trained and by hired coolie labour.

The 40 Lascars were for some reasons never enlisted, and in 1885, the establishment of natives (Sappers and Miners) was increased and fixed as follows:—

	Natives.
Calcutta	45
Rangoon	45
Bombay and Karachi	28

It was found that the position of the "Torpedo" officer as Assistant Adjutant-General was a false one, and in September, 1882, Capt. Featherstonhaugh was placed directly under the orders of the Inspector-General of Military Works, with the title of "Inspector of Submarine Defences," a title which remained unchanged up to 1907.

The period between 1882 and 1888 was occupied in the preparation of complete schemes for each port, the organization of stores, provision of suitable buildings and the necessary flotilla, and training the *personnel* above sanctioned.

Capt. Featherstonhaugh's appointment expired on 1st April, 1884, and he was succeeded by Capt. C. C. Carter, R.E. The submarine mining officers during these years made every possible effort to render the Sappers and Miners efficient, but evidence accumulated that Sappers and Miners, enlisted as they were from men of shore-going occupations, made very indifferent submarine miners.

In 1888 matters came to a head. Capt. Rice, the submarine mining officer at Karachi, became Officiating Inspector of Submarine Defences, owing to the death of Capt. Carter, and at once made a special report, drawing attention to the proved impossibility of rendering the *personnel*, so obtained, efficient. The unsatisfactory state of affairs had already been recognized, and a Special Committee, which met at Simla on the 6th September, 1888, and following days, made certain recommendations, but the Committee cannot have appreciated the main difficulty, as they still adhered to the "Sapper and Miner" system of obtaining native *personnel*.

Capt. Rice, in his very able report, submitted two alternatives :—

First. That the Submarine Miners should be a separate corps under the Inspector of Submarine Mining Defences, who should be the Commandant, and the native portion locally enlisted from men accustomed to boat work. Or

Second. Dispensing with natives altogether except for coolie work, and forming an "Indian Submarine Mining Battalion, Royal Engineers," composed wholly of officers and men of the Royal Engineers, divided into four companies at each of the four Indian submarine mining ports.

It remained for Major Von Donop, who was appointed Inspector of Submarine Defences in February, 1889, to work out the details of the scheme suggested by Capt. Rice. This he did in May, 1889, in a very complete manner, adopting Capt. Rice's second alternative.

The matter was subjected to exhaustive noting and discussion by the Government of India, who decided to give effect to the main recommendations of Major Von Donop, but were not prepared to go as far as to dispense altogether with native assistance.

The result was Government agreed to certain modified proposals for the formation of an Indian Submarine Mining Company, under command of the Inspector of Submarine Defences. Sanction of the Secretary of State was given on 12th June, 1890, but it was not until 15th October, 1891, that an Army Circular was issued giving effect to the scheme.

The total establishment of the Indian Submarine Mining Company was 1 Major as O.C. and I.S.D. in India, 4 Subalterns, and 74 N.C.O.'s. Submarine Mining Defences were authorized at the four ports of Calcutta, Bombay, Karachi, and Rangoon.

Associated with the Indian Submarine Mining Company was a corps of 140 native Lascars, who were authorized by India Army Circulars, dated April, 1891.

Under these new conditions the efficiency of the Submarine Mining Service in India rapidly increased. Natives of a proper class were enrolled, and proved themselves capable of being trained to a high degree in the water work and less technical portion of the shore duties.

This organization continued until 1902, and proved on the whole satisfactory.

In 1894 Capt. H. E. Tyler succeeded Major Von Donop as I.S.D. in India. In addition to completing the development of the new scheme of *personnel*, he did a great deal to bring the details of stores into line with the improved patterns in use at home. At this time not only were there a very large proportion of old pattern mines in

India, but new supplies were obtained direct by the India Office, and as the latter had no technical adviser, contractors naturally passed on to them any stores which had been rejected by the English service. Major Tyler arranged for stores ordered from India to be inspected at Woolwich, and thenceforward supplies proved satisfactory.

But money was very difficult to get in India at this time, and the defences, especially the electric lights, were so starved that in one report Major Tyler says that the Chinese ports are probably better defended than the Indian ones, *they could not be worse*.

In 1899 Major A. M. Stuart succeeded Major Tyler. In addition to the reorganization of 1902, dealt with below, he was able to develop the electric-light defence, for which funds were now available, and to start a system of electrical communications. In addition he had to deal with other branches of electrical work in India.

The chief alterations introduced by the reorganizations in 1902 were as follows :—

(*a*). The position of the officers was defined.
(*b*). The Indian Submarine Mining Company (Europeans) and Corps of Submarine Mining Lascars (Natives) were amalgamated into one "Indian Submarine Mining Corps," under the Inspector of Submarine Defences in India as Commandant.
(*c*). The Submarine Mining Lascars received the privileges of fighting men.

One further change was introduced on 1st October, 1903, the object being to bring the Indian Submarine Mining Corps as regards Europeans more into line with the organization of submarine mining companies at home. The changes now made were mainly :—

(*a*). The Royal Engineer establishment was made to comprise a certain number of sappers (previously all were non-commissioned officers).
(*b*). Their tour of service was four years, with possibility of extension if efficient.
(*c*). Abolition of local rank.
(*d*). Addition of mechanists.

It is interesting, in view of the attempt sometimes made to introduce a separate long-service army in India, to note the failure of this system as applied to the Europeans of the Indian Submarine Mining Company. These were all picked men, and all ranked as N.C.O.'s, but it was found that after a few years their health and energy suffered, and in several cases this led to drink and other military crime.

The experiment shows conclusively that four years is a sufficient time for N.C.O.'s or men to serve in the coast defences of a tropical port.

In June, 1900, a section of the Indian Submarine Mining Corps, consisting of 1 officer, 2 mechanists, and 6 other ranks, with 4 native mechanics, was authorized for Aden. The duties of the section are to maintain and work the electric defence lights, telegraphs, telephones, and to maintain other electrical communications.

As no Volunteer assistance is obtainable at Aden, the section was increased to 15 on the 6th January, 1905. There was no submarine mining work at Aden.

A decision was arrived at towards the end of 1905 to abolish the submarine mining defence on the Hughli; consequently from 1st April, 1906, the strength of the Calcutta Company was reduced from a company to a section comprising 1 officer, 8 British non-commissioned officers and men, and 10 native ranks. The section is considered sufficient to maintain the defence lights in peace time, and to provide the necessary skilled supervision in time of war, assisted by a strong local company of Electrical Engineer Volunteers.

In connection with the defences at Madras, a search light was installed at the harbour entrance at the end of 1905. This necessitated a small permanent establishment, and a small increase of the Indian Submarine Mining Corps was asked for.

The decision to introduce electric lighting and electro-mechanical punkah-pulling in barracks and cantonments has indirectly affected the Indian Submarine Mining Corps. It resulted in 1902 in the transfer of the I.S.D.'s Office to Simla, and that officer (Major A. M. Stuart, R.E.) organized and took charge of the Electrical Section in the office of the Director-General of Military Works in addition to his other duties.

Major Stuart, assisted by Capt. C. O. Halliday, R.E., designed and carried out with complete success the difficult work of electric lighting of the Central Camp and Delhi Fort at the Coronation Durbar at Delhi in 1902 and 1903. Various non-commissioned officers from the Indian Submarine Mining Corps were employed in this work, and rendered valuable assistance.

The arrangements under which the Inspector of Submarine Defences in India takes charge of the Electrical Section in the Director-General of Military Work's Office has continued up to 1907.

The electrical power stations have provided a few openings for capable N.C.O.'s of the Indian Submarine Mining Corps, and five of them have now been transferred to the Military Works Services for this duty. They have all done well, and have added to the reputation enjoyed by submarine miners as the "handy men" of the British Army.

A great deal of official literature exists on the subject of raising Volunteer companies to assist the Regulars with submarine mining and electric lighting. The idea was first mooted apparently by Major Von Donop in 1891, but it was not till 1894 that the companies were raised.

The Submarine Mining Volunteer Companies had only a brief career, and did not turn out altogether a success. The reason is obvious. Volunteers in India at the ports are a very superior body of men, many of them Europeans in good positions. They were unable to spare the time to make themselves efficient at the higher technical branches of submarine mining, and the rough-water work is better done by Lascars.

Two companies only were raised of Submarine Mining Volunteers, at Rangoon and Calcutta. The former was disbanded in December, 1904; the latter has practically ceased to exist owing to the abolition of submarine mining on the Hughli.

It is very different with the Electrical Engineer Volunteer Companies, one company having been raised at each of the four ports, Karachi, Bombay, Calcutta, and Rangoon, and with the exception at Bombay, are at full strength. The men are drawn largely from the electrical and mechanical workshops at the various ports, and the technical work of defence electric lighting being similar to their civil duties, many of them become rapidly efficient, and take a praiseworthy interest in the work.

Vessels and boats have during the whole period of submarine mining in India been provided by the Royal Indian Marine, together with their equipment and *personnel*.

The arrangement has, on the whole, worked satisfactorily, and the flotilla both in quality and quantity will stand comparison with that provided at any port in the Empire.

Details of Indian Submarine Mining Corps.

The early records of submarine mining in India are not very complete prior to 1884, in which year Capt. C. C. Carter instituted a system of annual reports which has continued to the present day.

The earliest training was probably in 1879, when A Company, Queen's Own Madras Sappers and Miners, under Lieut. C. H. Darling, and a Company of Bombay Sappers and Miners, under Lieut. O'Sullivan, were sent to Butcher's Island to be instructed by about a dozen N.C.O.'s who had arrived from England in charge of the first batch of stores. Other officers with the companies were Lieuts. M. J. Slater and W. J. Coles. But on the outbreak of the Afghan War the same year, both companies were sent to the front accompanied by their European N.C.O.'s, and never resumed their training.

Nothing more was done for a year or two, but in 1883 or 1884 detachments of Sappers and Miners were formed at the four ports, the first officers being Lieuts. Randolph at Calcutta, B. B. Russell at Bombay, S. R. Rice at Karachi, and C. C. Ellis at Rangoon. The latter was not a trained submarine miner; Lieuts. Randolph and Rice had been trained locally in India.

Officers only remained at the submarine mining work for a term of three years, after which they were transferred to the Military or Public Works, or in some instances to the Survey.

In 1889 the total establishment of officers was raised to six, second officers being appointed at Bombay and Rangoon.

At this time officers of the Submarine Mining Company were denied all opportunity of active service, and on this being represented, it was decided to take them in turn with others. In 1890 Lieut. Le Breton-Simmons was employed with the Black Mountain Expedition, and in subsequent years several officers—Leslie, Weekes, Halliday, and others—were employed on active service.

The establishment of officers was increased by one in 1900 for the Aden detachment, and in the reorganization of 1902 a second officer was added at Calcutta and Karachi, and it was decided that the companies should be commanded by captains, thus reproducing the organization of the companies of Royal Engineers at the Eastern ports which had been arrived at some 10 years earlier.

The following is a complete list of officers commanding sections and companies of the Indian Submarine Mining Service :—

OFFICERS IN CHARGE—ASSISTANT ADJUTANT-GENERAL.

Capt. G. M. Collings ... ... 1877.
Capt. A. Featherstonhaugh ... ... 1878.

INSPECTORS OF SUBMARINE DEFENCES.

Capt. A. Featherstonhaugh... ... ... 1882.
Capt. C. C. Carter ... ... 1884.
Capt. S. R. Rice (acting) ... ... 1888.
Major P. Von Donop ... ... 1889.
Major H. E. Tyler ... ... 1894.
Major A. M. Stuart ... ... 1899.
Major W. P. Brett ... ... 1904.

KARACHI SECTION—HEADQUARTERS, MANORA.

In Command.

Lieut. S. R. Rice ... ... 1883.
Lieut. G. F. H. Le Breton-Simmons ... 1888.
Lieut. G. A. J. Leslie ... ... 1892.
Lieut. H. W. Weekes ... ... 1894.
Lieut. G. A. Beazeley ... ... 1896.
Lieut. R. St. J. Gillespie ... ... 1897.
Lieut. H. G. Le Mesurier ... ... 1899.
Lieut. G. H. Willis ... ... 1901.

Formed into a Company, 1903.

Lieut. G. F. F. Osborne	1903.
Lieut. J. A. McEnery	1904.
Lieut. J. S. Barker	1905.
Capt. M. B. H. O'Donel	1906.

BOMBAY SECTION—HEADQUARTERS, BUTCHER ISLAND.

In Command.

Lieut. B. B. Russell	1883.
Lieut. A. C. Painter	1887.
Lieut. E. A. Tudor Jones	1890.
Lieut. G. J. L. Home	1892.
Lieut. F. M. Close	1893.
Lieut. C. O. Halliday	1894.
Lieut. F. M. Beazeley	1895.
Lieut. F. P. Rundle	1895.
Lieut. T. D. Broughton	1897.
Lieut. H. G. Le Mesurier	1898.
Lieut. G. F. F. Osborne	1899.
Lieut. J. A. McEnery	1901.

Formed into a Company, 1903.

Capt. C. O. Halliday	1904.
Lieut. C. L. John	1905.
Capt. R. St. J. Gillespie	1906.

CALCUTTA SECTION—HEADQUARTERS, FORT WILLIAM.

In Command.

Lieut. A. H. Randolph	1882.
Lieut. W. J. D. Dundee	1885.
Lieut. N. G. Von Hugel	1888.
Lieut. A. J. Pilcher	1892.
Lieut. A. G. Bremner	1893.
Lieut. C. O. Halliday	1896.
Lieut. A. Rolland	1895.
Lieut. F. A. Iles	1899.
Lieut. L. N. Malan	1901.

Formed into a Company, 1903.

Lieut. P. G. H. Hogg	1903.
Major E. H. Haig	1905.

Reduced to a Section.

Lieut. J. S. Barker	1906.

RANGOON SECTION.

In Command.

Lieut. C. C. Ellis	1884.
Lieut. F. Baylay	1888.
Lieut. A. J. Pilcher	1890.
Lieut. D. Brady	1892.
Lieut. A. Rolland	1895.
Lieut. T. D. Broughton	1898.
Lieut. H. O'H. Moore	1901.
Lieut. V. Giles	1902.

Formed into a Company, 1903.

Capt. H. M. Kelsall...	1903.
Capt. J. R. Garwood	1906.

ADEN.

Lieut. G. H. Willis	1900.
Lieut. W. E. Barron	1901.
Lieut. N. D. E. Dawes	1902.
Lieut. D. C. R. Hill...	1904.
Lieut. R. E. Stace	1905.

Though hampered in the early stages by want of men and stores, in the later days the submarine mining defences were maintained in excellent order. It was customary to assess the value of the mine-fields in "mine-days," which was the sum of the number of days each mine was out in the water. The number of effective and non-effective days could then be assessed, and it was rare to find the figure of merit or percentage of good mine-days less than 97 per cent. In the Karachi practices of 1901–02 and 1902–03, out of 4,349 and 4,382 mine-days respectively only five were bad each year, a figure of merit of 99·99 !

In 1902 a system of challenge cups was instituted for musketry, rowing, and sailing. The first was allotted on the figure of merit of the annual course; the other two were awarded by the I.S.D. to the section which turned out the best-manned gig and the smartest and best-handled sailing junction-box boat. The results were :—

MUSKETRY CUP.

1902–03	No. 1 Company, Karachi.
1903–04	"
1904–05	"
1905–06	Aden Section.

Sailing Cup.

1902–03	...	...	No. 1 Company, Karachi.
1903–04	...	...	„
1904–05	...	...	„
1905–06	...	...	„

Rowing Cup.

1902–03	...	...	No. 2 Company, Bombay.
1903–04	...	...	No. 1 Company, Karachi.
1904–05	...	...	„
1905–06	...	...	„

Mines were withdrawn at all Indian ports in 1907, and the future of the Submarine Mining Service is still under consideration.

CHAPTER XI.

SUBMARINE MINING IN THE BRITISH COLONIES.

THE principal submarine mining defences in the Colonies were those in Australia and New Zealand, but in addition a start was made in 1888 with a defence of Cape Town and Simons Bay; a submarine mining establishment was constructed at the latter place and local efforts were made to train a Volunteer Company.

On the withdrawal of the Imperial Garrison from Canada in 1904, the local forces took over the responsibility for the mine defences of Halifax (Nova Scotia) and Esquimault.

A Volunteer Company was formed at Hong Kong in 1899 to assist with the electric lights, and a similar company was formed at Singapore about 1904.

The mine defences of the principal Australian ports began about 1871, concurrently with the first development at home, but were not made effective till 1877, when Sir William Jervois, who had been made Governor of South Australia in 1877, and Lieut.-Colonel P. H. Scratchley, R.E., were detailed to report on the defences of the various ports, and the latter officer was detailed to form the necessary local corps.

It is often urged that the defences of the Colonies have been constructed without proper consideration of the general principles of naval defence, and thus it will not be out of place to quote *verbatim* a speech delivered by Colonel Scratchley, R.E., in December, 1878.

It was delivered in Hobart Town, Tasmania, to a meeting of officers, non-commissioned officers and men of the local forces, after an inspection by Colonel Scratchley. Some details of purely local interest are omitted, but the remainder is repeated exactly as it was reported by *The Mercury*, a leading newspaper of the town.

"I have taken this opportunity of meeting the officers and non-commissioned officers of the Volunteer Force at Hobart Town in order to deliver a short address on the defence question, because I deem it to be of great importance that the principles upon which we are working should be well understood by all those who are called upon to co-operate in the establishment and working of the scheme of defence; and we must endeavour to counteract the want of experience and training by bringing the intelligence of the officers and men to bear upon the subject.

"I am satisfied that, when these principles are explained, the objections which have been urged against Sir William Jervois' scheme will be found to have no foundation, and it will be seen that most of the criticism which has passed on the subject has proceeded from a complete misunderstanding of these principles.

"In his memorandum upon the defences of Tasmania, His Excellency Sir W. Jervois begins the consideration of the subject by noticing the important position which Tasmania occupies with reference to the general defence of the Australian colonies, and by stating that an enemy might operate with facility against their commerce by occupying one of the fine harbours of the island.

"He then proceeds as follows :—'A hostile occupation of the harbours referred to can however only be prevented by naval means, for the provision and maintenance of which Tasmania has not sufficient resources. The defence of those harbours against such occupation must be considered in connection with that of the coast and harbours of the adjacent Colonies; and the number and description of ships of war required for this purpose—whether as regards the Imperial Naval Squadron on the station or colonial vessels—will more properly be dealt with in a report upon the naval defence of Australia generally.

"'The recommendations in the present memorandum will therefore be restricted to such measures as are requisite for protection against attack by a cruiser or privateer, and as are within the means of Tasmania to afford.

"'As before remarked, it would be out of the question to provide local defences to prevent the occupation by an enemy of the numerous harbours upon the coast of Tasmania. It is however practicable to protect Hobart Town against the attack of an unarmoured vessel of war, which eluding our naval squadron, and in the absence of sufficient defences, might, under threat of bombardment, or after actually firing into the place, levy a heavy contribution upon the colony.

"'The width of the Derwent below Hobart Town being from 4,000 to 5,000 yards, the depth of water being sufficient for vessels of any size, and the passage perfectly clear, it would be out of the question, by means of land batteries, to prevent an enemy's vessel steaming rapidly up the river and occupying a position whence she might throw shells into the city. If however batteries be established which would bring an effective fire to bear upon her when she lay opposite the town, and if a line of obstructions be placed in such a manner as to prevent her running up the river beyond the town and out of fire from the batteries, she could neither remain in such a position nor get to any point whence she could effect a bombardment. *She would then be obliged to retire. It is on this principle that the defence of Hobart Town should be based.*

"'The artillery fire from One Tree Point, Kangaroo Point, and Queen's Battery, in conjunction with the torpedoes between Macquarie Point and Montagu Point, will defend Hobart Town against an unarmoured vessel, but an attack might possibly be made by a small force landing at one of the bays within a few miles distance and marching along one of the roads which converge therefrom towards the place.

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"'To meet such contingencies, as also to defend the batteries against assault, there should be, in addition to the gunners required for the batteries, a small body of Volunteers, partly infantry and partly artillery, organized and maintained as a field force. In the event of a hostile body landing at any of the bays in the neighbourhood, this force should oppose the enemy at the most favourable points—which should be previously selected—and obstacles to an advance should be created by throwing up earthworks for field guns and infantry, cutting down trees, forming entanglements of branches and wire, and by other means.'

"If we look closely into these recommendations we perceive that the leading idea is the same as that upon which the schemes of defence suggested for the other Australian colonies are based. Sir W. Jervois closes the principal ports of the Colonies against an enemy's ships by means of batteries and torpedoes; he provides land forces to repel any attempt at landing, and he leaves to naval means the protection of commerce generally, as well as the prevention of the occupation of the minor harbours along the coast. It is satisfactory to find that, notwithstanding the criticisms which have been freely offered, the soundness of Sir W. Jervois' views and recommendations has, without exception, been universally admitted.

"Furthermore, Commodore Hoskins, the naval commander of the Australian station, in a letter to His Excellency the Governor, puts the defence question in the clearest light.

"The opinion of so high an authority is worthy of the most careful attention, and I will quote his words at length:—

"'The effective strength of the Australian Squadron under my command at present consists of four ships, including my own pendant ship. With this force, as at present advised, in the event of war being declared, the interests of eight colonies will have to be cared for, and their commerce as far as possible protected.

"'The principal duty of the commander of a naval force is to meet a hostile squadron wherever it can be found and endeavour to stop its ravages *in limine*, and not by dividing and shutting up his ships in the different ports, to give the enemy the command of the sea and the power of attacking them separately and in detail. *He has a right to expect that the principal ports shall be protected by land forces and batteries, either afloat or on shore*, sufficiently strong to protect them against an ordinary cruising squadron; and by heading it off, or delaying it, to give him a better chance of intercepting it, and also to afford him a refuge and shelter in case of his being worsted or overpowered in a sea fight.

"'*To call on ships to protect the ports, instead of the ports the ships, is to invert the obligation* and prevent their performing their proper duties. Should the enemy not send a squadron to these seas, but only single cruisers, acting independently against our commerce, corresponding steps would of course be taken; but even then, to enable detached vessels to act with vigour and success, it would be necessary for them to have fortified places to fall back upon in case of need.

"'It will be evident from what I have said that I can enter into no engagement to give Hobart Town the preference over any other of the

Australian ports, and that the steps I may think it right to take in the event of war being declared must depend on the information received as to the nature of the attack or molestation to be expected; and that on such a wide and extended station *no place can be safe from an isolated attack and being placed under contribution which is not properly fortified and protected by its own defences.*'

"Thus you will see that the Commodore leaves no choice open in dealing with the defence question in Tasmania, and that he completely disposes of the proposal which has been made to the effect that the defence of the two principal harbours of the island should be undertaken by the Imperial Navy.

"Now I cannot insist too strongly upon the absolute necessity of combining all the elements of defence in due proportion, so as to produce a complete and harmonious whole. It needs no demonstration to show that torpedoes without guns to protect them, or batteries without torpedoes, will not prevent an enemy's ship entering a harbour, or that batteries and torpedoes without land forces will be useless against landings.

"It is owing to this loose mode of looking at a scheme of defence in detail, instead of as a whole, that the principles upon which it is based are so readily lost sight of. Some critics, for instance, question the efficacy of torpedoes, and assert that naval officers undervalue their employment, as they can readily be removed by countermining and other well-known means. Now the very reverse of this opinion prevails among the best naval authorities. They admit that only in very special cases will it be possible to attempt to force a passage defended by torpedoes, provided they are adequately protected by strongly-constructed forts or batteries.

"The recent attack made by the Navy at Portsmouth against defensive torpedoes being conducted without that all-important element of defence —guns on shore firing at the ships and boats—absolutely proves nothing. The experiments were useful as affording the Navy an opportunity of practice, and to the Engineers they showed the weak points in the working of a system of submarine mines.

"What was done at Portsmouth with ease in time of peace would only be achieved in time of war by sacrifices of life and material, which would only be justifiable where the end to be gained was of paramount importance. *I may therefore safely assert that no enemy will attempt to force a passage into any harbour of the Australian Colonies, provided it is defended upon the combined system of batteries and torpedoes recommended by Sir W. Jervois.*

"I now come to that portion of the subject in which you are more particularly interested—the force provided for the working of the scheme of defence. It is very evident that success will depend upon the degree of efficiency attained.

"It is as necessary to bring common sense to bear upon, and to apply the ordinary rules of business in the management of a military machine as in the conduct of any other large undertaking. It would be as absurd to attempt to conduct a manufacturing establishment without a proper staff of experts to direct the workmen in their several branches as to endeavour to manage a military body without a competent staff. The

Defence Force recommended by Sir W. Jervois for Tasmania, as you are aware, will comprise:—

"1. A small nucleus of regular paid soldiers, who will take charge of the batteries and armaments, warlike stores, etc., and be immediately available for manning the guns until they could be reinforced by the Volunteers. If this small body were not maintained, civilians would have to be employed at a far greater cost to do the work in time of peace, and in time of war there would be no trained men for the defences. The smallness of the force has been regulated by the money available. It can at any time be increased if so desired.

"2. A Volunteer force consisting of artillery and infantry—the artillery for the field guns attached to the infantry and for manning the guns in the batteries; the infantry to resist any attempt at landing. In order that the whole of the infantry may be available for this purpose, the batteries are to be made self-defensible against assault, and quite independent of the immediate protection of the infantry. This is a point to which Sir W. Jervois attaches the very greatest importance.

"3. A small torpedo and Engineer Corps, which will be responsible for the submarine mines and for the fieldworks required. It will be necessary that the torpedo men should be thoroughly instructed in time of peace in all the details of the submarine mines. The error of postponing all preparations and training until war is declared must be avoided. Success in this portion of the defensive arrangements will entirely depend upon the degrees of preparation in time of peace.

"To me, an Imperial officer, who in the execution of my professional duties has to visit five out of the seven Australian colonies, it is especially gratifying to find—whether I am in Rockhampton, to the north, or in Adelaide, to the south, in Sydney, Melbourne, Hobart Town, or Launceston—the same determination exists, not only on the part of the Governments, but of the people and their representatives in Parliament, to adopt the necessary measures for rendering this portion of Her Majesty's dominions secure against foreign aggressions. Moreover, I believe that what is being done now in defence matters in this colony will be lasting, and that we have made a satisfactory beginning in the establishment of a sound and permanent system of defence."

In 1885 the Russian War scare, which had such an effect on the development of the English Service, produced similar activity in Australia, and the mining defences were actually laid out. There were no R.E. officers available, so naval officers were placed in temporary charge.

The services of R.E. officers were at the same time applied for from the Home Government, and Capt. Rhodes was sent out to Melbourne and Capt. Penrose to New South Wales, while in 1886 Mr. Mathieson, late Sergeant-Major, R.E., was sent out to Tasmania.

The growth of the various corps from this date is shown in the detailed account of each colony.

In 1902, on the formation of the Commonwealth, the corps were reorganized, and several of the submarine mining officers joined the staff of the forces of the Commonwealth.

The submarine mining defences have been continued in Australia to 1908.

Up to the time of the abolition of mines at home, the Australian Colonies followed home patterns and methods, and all the officers of the Permanent Forces went through courses in England.

Submarine Mining in New South Wales.

The Torpedo Corps, which was started about 1871, was originally attached to the Naval Brigade, of which the late Colonel Cracknell, Major Walker, and Lieut. Kopseh were the officers.

Upon the recommendation of Colonel Scratchley and Sir William Jervois, who reported in connection with the defences of Sydney, a Torpedo and Signalling Corps were formed on a Militia basis about December, 1877, and the first officers were Major Cracknell, Capt. Walker, Lieuts. Wilson, Dalgarno, and Kopseh. The duties of this corps were to undertake the submarine mining work and signalling.

The *personnel* was mainly recruited from employees of the Electric Telegraph Department, together with some engine drivers and other artisans.

A few years after this corps had been in existence it was decided by the State Government to provide a couple of torpedo launches and two small boats—the *Avernus* and *Acheron*—which were constructed at Morts Dock Engineering Works under designs by Mr. Norman Selfe. These boats were run by the Torpedo and Signalling Corps for some years, and were finally handed over to the Naval Volunteer Artillery, which was attached to the Naval Brigade.

In 1885 Capt. C. Penrose, R.E., was appointed to command the Engineer Forces in New South Wales, with the local rank of Major.

The Corps of Permanent Submarine Miners was raised in 1888, with a total establishment of 2 officers and 22 N.C.O.'s and men.

Major Penrose was at the same time appointed Brevet Lieut.-Colonel to command the submarine mining forces of the Colony, J. H. A. Lee, Esq., being appointed Captain of the Permanent Submarine Miners, while Mr. W. O. Woods, R.E., was appointed Instructor.

A detachment of Royal Engineer Instructors (N.C.O.) arrived in the Colony 18th March, 1889, under a five years' engagement, and were followed shortly afterward by Lieut.-Colonel F. de Wolski, R.E., who was appointed Commanding Engineer, in succession to Lieut.-Colonel Penrose, whose term of engagement had expired. Mr. W. O. Woods, R.E., whose term of engagement had also expired, returned to England 22nd February, 1890.

On 3rd April, 1891, during the Easter encampment, occurred the disaster at Middle Head by which Lieuts. Hammond and Bedford, of the Militia Submarine Miners, Corpl. McKee, R.E., and Bugler Bennett, of the Permanent Submarine Miners, lost their lives, and a number of others of the Militia, or Partially Paid Branch, were seriously injured.

Nothing further of any note occurred until July, 1893, when the Corps of Engineers was reconstructed, the old Corps of Partially Paid Submarine Miners, or "Torpedo and Signalling Corps," as it was more commonly called, being formed into two companies, called respectively No. 3 Company, N.S.W. Engr. "P.P.S. Miners," under Capt. A. Broughton, with whom were Lieuts. A. Talbot, F. S. Horsley, and P. C. Day; and No. 4 Company, N.S.W. Engr. "Electricians," under Capt. and Brevet Major P. B. Walker, with separate sections for "Field Telegraph," "Electric Lights," and "Coastal and Electric Communications," under Lieuts. I. Y. Nelson, A. C. F. Webb, J. S. Alexander. The Permanent Submarine Miners, under the command of Capt. J. W. A. Lee, were attached to and formed part of No. 3 Company.

A detachment of Permanent Submarine Miners consisting of nine N.C.O.'s and men were sent to England 26th April, 1897, for instruction in submining at the principal submarine mining stations with Imperial troops, returning to New South Wales 21st October, 1897.

On the outbreak of the South African War a number of the N.C.O.'s and men of the company volunteered for active service, also the O.C.S.M. Seven only of the men were sent, they joining the Australian Army Medical Corps, and Major J. H. A. Lee, O.C.S.M., who went as Second in Command of the 1st A.C.H. All returned safely.

Three men also were sent to China with the naval contingent, upon outbreak of hostilities there; and one man went to England as representative with the Coronation contingent.

In 1902, upon the formation of the Australian "Commonwealth," the N.S.W. Engineers were again reorganized and reconstructed. The Engineer forces of the Commonwealth being classified as a whole, those of New South Wales being numbered respectively No. 1 Field, No. 1 Submarine Mining, No. 1 Electric, and Half-Company No. 4 Field Companies, Corps of Australian Engineers "Militia."

The Permanent Submarine Miners, now with an establishment of 1 officer and 36 N.C.O.'s and men, still continued to form the permanent unit of No. 1 Submarine Mining Company, and in June of the same year the unit was reduced to 1 officer, 24 N.C.O.'s and men, which, with a Militia establishment of 5 officers, 75 N.C.O.'s and men, made the total strength of the company 105 of all ranks.

In the financial year 1905–6 the establishment of the Permanent Section, No. 1 Submarine Mining Company, was again increased by the addition of 1 corporal and 6 sappers, bringing up the strength of the company to 112 all ranks.

OFFICERS OF THE NEW SOUTH WALES FORCES.

Commanding Engineer.

(Local) Lieut.-Colonel C. Penrose, R.E.	1885 to 1889.
(Local) Colonel F. R. de Wolski, R.E.	1889 to 1891.
(Local) Colonel H. W. Renny-Tailyour, R.E.	1891 to 1894.
Lieut.-Colonel T. Rowe, N.S.W. Engineers.	1894 to 1898.

Staff Officer.

P. T. Owen, N.S.W. Engineers (Capt. 1895, Major 1901, Lieut.-Colonel 1902).	1895 to 1903.

Permanent Force.

J. H. A. Lee (Capt. 24th Sept. 1888, Major 1st Jan. 1894, Lieut.-Colonel 3rd April 1903).	In Command, 1888 to 1903.

On the reorganization under the Commonwealth, Lieut.-Colonel Owen and Major Lee became members of the permanent Corps of Australian Engineers.

Militia (Partially Paid) Force.

E. C. Cracknell (Major 8th Oct. 1877, Brevet Lieut.-Colonel 6th April 1880).	Commanding, 1877 to 1894.
P. B. Walker (Capt. 6th Feb. 1879).	
A. Broughton (Capt. 18th Dec. 1889).	

DIVIDED INTO TWO COMPANIES.

No. 3 Company (Submarine Miners).

A. Broughton (Capt. 18th Dec. 1889).	Resigned, 1898.

No. 4 Company (Electricians).

P. B. Walker, V.D. (Capt. 6th Feb. 1879, Major 27th Nov. 1893, Brevet Lieut.-Colonel 29th March 1899).	Commanding and Director of Military Telegraphs, 1894 to 1898, D.M.T., 1898 to 1903.
I. Y. Nelson, V.D. (Capt. 27th Nov. 1893, Major 1st Nov. 1900).	D.M.T., 1903.

Submarine Mining in Queensland.

The first attempt at submarine mining was in 1882, when extemporized charges were laid.

In 1884 the Defence Act became law, and in 1885 a number of men were sent to Lytton at the entrance to the Brisbane River, their work being to fortify the place; observation mines were laid and the river was boomed. Q.M.S. Lewis, R.E., was at this time Instructor to the Corps; this N.C.O. afterwards became Hon. Captain.

In 1888 Capt. E. Druitt, R.E., was appointed to take charge of the Engineer Services of Queensland, including the mine defence at Brisbane. On his departure in 1893 the work devolved on a local officer.

The Submarine Miners were a detachment of a Militia Company of Brisbane Engineers, under Capt. T. Tomlinson.

In 1898 the organization was brought into line with that of the other colonies, viz., a small permanent force and a stronger Militia or partly paid force to assist.

On the reorganization in 1902, the Queensland Submarine Mining Company became No. 3 Submarine Mining Company of the Forces of the Commonwealth. Capt. C. H. Foott was appointed Staff Officer for Engineer Services and Commanding the Permanent Section, Queensland, with Capt. J. Hesketh in command of the Submarine Mining Company of Militia.

Submarine Mining in Tasmania.

The Tasmanian Torpedo Corps was formed under the guidance and organization of Major-General Scratchley, R.E. Military Adviser to the Colonies, on January 1st, 1883. Capt. Edmund Tudor Boddam, R.A., Staff Officer, Tasmania, afterwards Lieut.-Colonel, N.S.W. (Local), was entrusted with its practical formation, and commanded the Corps until 1886, when he went to New Zealand, and Mr. Mathieson, late Sergt.-Major R.E., was sent out from England by General Harding Steward, R.E., to take command.

Mr. Mathieson went home in 1890 and died there some years later.

In 1885 the corps had an R.E. Instructor named Faulkner, who afterwards went to New Zealand and became Captain (Local) Commanding the Submarine Miners there.

On the formation of the corps, Mr. Robt. Henry, recently deceased, late Superintendent of Telegraphs, Tasmania, was appointed Electrician with the rank of Lieutenant, and eventually became Major Commanding the Corps.

The scheme was a minefield to protect the upper reaches of the river Derwent, embracing in its details 36 100-lb. E.C. pear-shaped mines, and during the annual training the mines were laid, tested, and made complete, and afterwards dismantled. There were also 12 250-lb.

observation ground mines for the river Tamar, but it does not appear that they were ever laid.

Submarine mining was dispensed with in Tasmania upon the formation of the Commonwealth, and in 1904 the Torpedo Corps became a section of Field and a section of Electric Engineers, under Capt. A. C. Parker.

NAMES OF OFFICERS OF TASMANIAN CORPS.

Torpedo Corps.

Robert Henry (Capt. 2nd July 1883, Major 27th June 1898).	In Command, 1883 to 1904.
H. E. Packer (Capt. 27th March 1899).	
A. C. Parker (Capt. 9th March 1900).	

SUBMARINE MINING IN THE COLONY OF VICTORIA.

In 1871, in consequence of the development of the appliances and practice of modern war, the Government of the Colony, at the instance of the military authorities, resolved to form a Volunteer Corps to undertake all matters connected with the making, loading, and submerging of submarine mines, or torpedoes as then named. This corps, with an establishment of 26, was organized under the title of "The Volunteer Torpedo and Signal Corps."

The command of the corps was entrusted to Capt. Couchman, an experienced officer of the Volunteer Force, and it was considered desirable that the corps should consist of men of good education and more or less professional standing.

The opportunity of belonging to a scientific Volunteer Corps had the effect of bringing applications from the professional branches of the Lands, Mines, Telegraph, and other Departments of the Public Service.

During the early years of the corps, economy was the order of the day. As a result, no mining practice was done for want of material. The work of the corps consisted almost entirely of practice in flag signalling and telegraphy, with theoretical instruction in electricity.

The first officers of this Volunteer Corps were :—

Major Couchman (afterwards Public Service Commissioner).
Capt. Ellery (Government Astronomer).
Lieut. McGowan (Superintendent of Telegraphs).

Towards the end of 1877 funds were provided for the purchase of some mining material, most of which was manufactured locally. For the storage of this material two old prison hulks, the *Sacramento* and *Deborah*, were made available and handed over to the corps on

April 1st, 1878. The *Sacramento* was used as a magazine ship and the *Deborah* as an equipment store ship.

Between 1878 and 1882, acting on the recommendations of General Sir William Jervois and Lieut.-Colonel P. H. Scratchley, R.E., the equipment was placed on a satisfactory basis, and the corps re-organized into a Militia force with a permanent section. This organization was brought into force on the 17th of July, 1882, the establishment being 87 all ranks. This included a Permanent Staff of six, part of which formed the crew of a mining launch, the *Miner*.

During 1882 storehouses were provided at Williamstown, and most of the stores removed thereto from the hulks.

1883 was a year of great activity, and large quantities of cable, gun-cotton, and other stores arrived from England. The Permanent Staff was increased to 11 by the arrival from England of five R.E. N.C.O.'s under engagement as instructors, storekeepers, etc.

During 1884 the submarine mining depôt at Swan Island was partially completed. All stores were removed there from Williamstown by 24th December, 1884.

During 1885 the "Russian War" scare occurred. There being no permanent officer in charge of submarine mining, the laying out of the defence was entrusted to Torpedo-Lieut. Hely-Hutchinson, R.N. Fifty-six buoyant mines were laid from a large specially fitted up pinnace, towed along by a steamer (s.s. *Despatch*). Ninety-six ground mines were laid from a flat-bottomed punt, towed in same manner.

Controlling test rooms were established in temporary structures on South Channel Fort (then being built) and the South Channel Pile Lighthouse.

During 1885-86 the Depôt at Swan Island was completed, and the Permanent Staff increased to 21. Towards the end of 1885 Capt. E. F. Rhodes, R.E., arrived from England under engagement, and was appointed O.C. Engineers. He was succeeded by Capt. Rainsford-Hannay, R.E., in 1889.

On 1st July, 1889, the Permanent Staff was increased to 31, including one officer; the first permanent officer was Lieut. J. W. Parnell, later Director of Engineer Services to the Commonwealth.

In 1890 this establishment was rearranged, a company sergeant-major giving place to another officer, and on 8th August, 1890, Lieut. G. F. Wilkinson was appointed to the Permanent Staff.

In 1894 Capt. F. Reynolds, R.E., who had come out to Melbourne as Garrison Instructor in 1891, succeeded Major Hannay as O.C.E. Capt. Reynolds returned to England on 30th June, 1896, and his place was filled by Capt. J. W. Parnell as Staff Officer for Engineers.

On 1st April, 1900, the establishment of the Permanent Staff was increased to 35.

In 1902 the transfer of the forces of the various colonies to the control of the Government of the Federated States forming the Commonwealth of Australia took place. These forces were then reorganized under a Federal scheme proposed by Major-General Sir E. T. Hutton, K.C.M.G., in which the permanent submarine mining establishment in each State was reduced.

The Engineer units of the Colony of Victoria were numbered No. 2 Field Company, No. 2 Electric Company, and No. 2 Submarine Mining Company, all with headquarters at Melbourne.

OFFICERS OF THE PERMANENT AND MILITIA FORCES.

Commanding Engineers.

(Local) Major E. F. Rhodes, R.E.	1885.
(Local) Major F. Rainsford-Hannay, R.E.	1889.
(Local) Major F. R. Reynolds, R.E. (Garrison Instructor 1891).	1894 to 1896.

Staff Officer for Engineers.

Capt. J. W. Parnell, Victoria Engineers (Major, Victoria Militia Forces, 1894).	1896.

Permanent Corps.

Capt. J. W. Parnell (Capt. 26th Aug. 1889).

Lieut. G. F. Wilkinson (Lieut. 8th Aug. 1890).

These two officers became members of the permanent corps of Australian Engineers on the reorganization under the Commonwealth in 1904.

Militia (Partially Paid) Corps.

R. E. Joseph (Capt. 19th March 1879, Major 1st Jan. 1889).	In Command, 1879 to 1900.
H. Moors (Capt. 15th March 1879.	Resigned, 1893.
M. L. Bagge (Capt. 1st Aug., 1897, Major 1st July 1899).	In Command, 1901 to 1907.
S. J. Masters (Capt. 1st July 1899).	

This corps was continued under the Commonwealth organization in 1904.

Commonwealth of Australia.

CORPS OF AUSTRALIAN ENGINEERS.

List of officers of the Permanent Forces serving in 1907 who have been trained as Submarine Miners.

Headquarters (Central Administration).

Major J. W. Parnell * ...	... Director of Engineer Services.
Capt. P. M. Buckley † ...	... Director of Works.

Regimental.

Lieut.-Colonel J. H. A. Lee ‡ ...	Commanding Permanent Section and No. 1 Militia Company, Submarine Miners, New South Wales.
Capt. G. F. Wilkinson § ...	Staff Officer for Engineer Services, and Commanding Permanent Section, Victoria.
Capt. C. H. Foott	Staff Officer for Engineer Services, and Commanding Permanent Section, Queensland.
Lieut. A. M. Martyn	Permanent Section, Victoria (under instruction).
Lieut. and Quartermaster R. E. Sheldon.‖	Instructor and Submarine Mining Storekeeper, New South Wales.

Submarine Mining in New Zealand.

The Colony of New Zealand went through very much the same stages as the Australian Colonies.

The presence in Australian waters of Sir W. D. Jervois and Sir P. Scratchley and the war scare of 1885 are the principal guiding marks.

The organization included, at each port defended by mines, a Permanent Force of about 30 Royal New Zealand Engineers and a Volunteer Force of about 120.

* R.E. Officers' Course, 1891, S.M.E., Chatham, and Portsmouth, and Refreshing Course, S.M.E., 1904.
† R.E. Militia Submarine Miners (Portsmouth), 10 years.
‡ R.E. Officers' Course, 1891, S.M.E., Chatham, and Portsmouth.
§ R.E. Officers' Course, 1893, S.M.E., Chatham, and Portsmouth.
‖ Late Royal Engineers (Submarine Miners).

In August, 1897, Capt. W. Coyle, of the Coast Battalion, R.E., retired from the English Service to take charge of the Submarine Mining Defences of New Zealand, which appointment he held till 1903.

Submarine mining has continued in use in the New Zealand ports to 1908.

PERMANENT MILITIA.

J. Faulkner (Capt. 1st Sept. 1887).	In Command, 1887.
W. T. Powell (Capt. 1st Oct. 1891).	Resigned, 1900.
S. Anderson-Cosgrave (Capt. 1st Jan. 1882).	Quartermaster.
W. Coyle (Capt. 3rd Nov. 1897)	Late Coast Battalion, R.E.

Electric Light Company at Hong Hong.

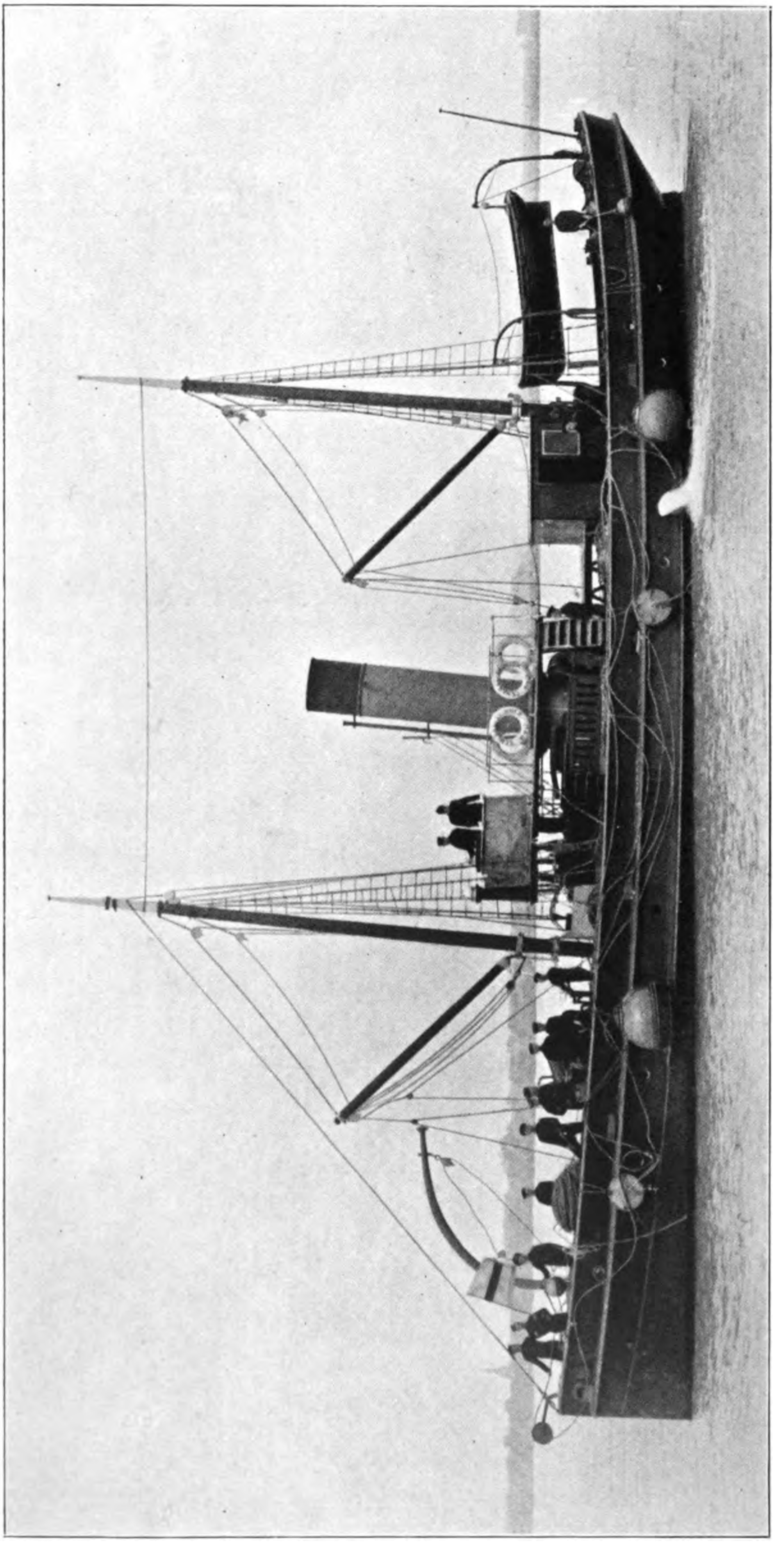
At Hong Kong the Electric Light Company was formed in 1899 to assist the Submarine Miners in manning the defence lights, and formed the Engineer Company of the Hong Kong Volunteer Corps. It included a very good class of men from the local Dock Company and similar establishments.

The first officer was Lieut. R. Mitchell, 13th June, 1899 (Capt., 10th July, 1902), with Lieut. J. W. Graham, and it has since been commanded by Capt. G. J. B. Sayer and Capt. W. A. Crake.

Electric Light Company at Singapore.

At Singapore the electric light was part of the work of an Engineer Volunteer Corps, formed about 1904, which was commanded by Capt. H. Pierce, 1904 to 1907.

LINE OF TWO 500-LB. BUOYANT MINES, SLUNG ON MASTED VESSEL.



CHAPTER XII.

DETAILS OF SUBMARINE MINES.—PATTERNS OF MINES AND CHARGES.—MOORINGS.—APPARATUS.—METHOD OF FIRING AND TESTING.—TEST ROOM AND FIRING STATION.

IN the earlier chapters the progressive development of the submarine mining material has been described in general terms as advancing under the fostering care of various Committees, and under the pressure of inventions by numerous individuals, many of whom came from the non-commissioned ranks. It is not possible to trace each invention to its source or allot to each individual his personal share of the credit for each improvement, as not only would space not admit, but many improvements have been polished by discussion in Committee, and in the progress of experiments in which several individuals took part.

It is therefore proposed in this and the following chapter to summarize as briefly as possible the principal details involved in a system of submarine mines, to make some attempt to show how these details were arrived at and to give the names of individuals who were specially concerned in any particular improvement or development of more than ordinary interest.

A submarine mine has been defined as "A charge of explosive, moored at or beneath the surface of the water, intended by its explosion to put out of action without delay a hostile vessel of the class it is intended to act against."

CHARGE OF EXPLOSIVE.

The first point to refer to is thus the charge of explosive. For this guncotton has by common consent been accepted as the best material ever since Mr. F. A. Abel in the sixties developed the method of compressing guncotton pulp into slabs, and Mr. E. O. Brown showed that wet compressed guncotton could be detonated by the use of a primer of dry guncotton and a detonator. It took a few years longer to convince Submarine Miners that wet guncotton was as efficient as an equal dry charge, and for some years a drying apparatus was issued to most submarine mining stations. Experiments gradually showed that, provided the charge was packed tightly together so as to form a practically solid mass, a charge wetted with not more than 25 per cent. of water was rather more efficient than a similar dry charge.

The wet guncotton was finally issued in slabs $6\frac{1}{8}'' \times 6\frac{1}{8}'' \times 1\frac{3}{4}''$ with a weight of $2\frac{1}{2}$ lbs. of guncotton in each. These were cut when required to fit the curved sides of cylindrical mines or round envelopes of apparatus.

The dry primer was at first enclosed in a waterproof bag, and was made up of two or three 9-oz. discs. But to ensure its dryness it was finally decided to enclose it in a metal envelope, and the size of primer was at the same time fixed at four 9-oz. discs, or $2\frac{1}{4}$ lbs. in all. To resist countermining, the metal envelope was subsequently strengthened, and at the same time the priming charge was increased to a weight of $4\frac{1}{2}$ lbs., made up of three $1\frac{1}{2}$-lb. discs.

Fuzes and Detonators.

To fire the primer, an electric fuze was first adopted, and as guncotton came into use, a charge of detonating composition (fulminate of mercury) was added, such an arrangement being called a detonating fuze, and subsequently "detonator."

As the detailed composition of the detonator had an important bearing on the electrical arrangements subsequently adopted, it is necessary to follow its development somewhat closely.

All patterns of fuzes or detonators can be grouped into one of two classes, called "low tension" and "high tension." Of these, the first depends for its action on the fact that if a portion of an electric circuit includes a short piece of fine wire, this piece will be heated red hot by the passage of a moderate current of electricity. By surrounding the wire by a small explosive priming, the ignition of a charge can be effected.

The "high-tension" fuze depends on the fact that when a discharge takes place between two conductors placed very near but not touching, a spark is produced, and this action can be intensified by placing between the conductors a loose mixture of some combustible material and another substance which will offer a considerable, but not too high, resistance to the passage of electricity. The effect is a succession of small sparks between the particles of the mixture and the ignition of the combustible agent.

The low-tension form was that first used for the electrical destruction of wrecks by Sir Charles Pasley in 1843, but difficulty seems to have been found in arranging a reliable priming, and it was also objected, as a voltaic battery had to be used, that a considerable number of cells was required to ensure ignition.

On the other hand, the high-tension fuzes required a higher degree of insulation in the connecting cables.

Experiments were therefore carried out by various inventors, and in 1856 Abel began a systematic series of experiments to determine the best arrangement of the wire terminals and the explosive composition best adapted to act as a *bridge*. The importance of this last point lay in the necessity of being able to pass some form of testing current through the fuze without firing it. After numerous experiments, Abel finally introduced a high-tension fuze composed of two copper poles placed side by side ·06″ from one another and embedded in gutta-percha, with a small quantity of priming (or conducting composition), which consisted of an intimate mixture of subphosphide of copper, subsulphide of copper, and chlorate of potash placed in a small paper cap and fixed over the poles.

The fuze was completed by a priming of meal powder, the whole held in a small cylindrical wooden case much of the dimensions of the present fuze. Abel's fuze proved sufficiently reliable to justify its introduction into the service, but its sensitiveness was affected by damp, and as its resistance varied within considerable limits, the electrical tests obtained were unreliable as a test of the efficiency of the fuze. Experiments were therefore continued, and about 1869 Lieut. Bucknill found that a low-tension fuze could be much improved by placing a small wisp of guncotton round the wire bridge and enclosing the whole in a gunpowder priming. This improvement is still in use with all service fuzes and detonators.

But the low-tension fuze was still somewhat irregular in its action, and while it was agreed that platinum must form the basis of the wire bridge, it was not till about 1873 that some experiments carried out under Capt. Fisher, R.N., definitely established the fact that a small quantity of iridium added to the platinum gave those qualities of reliability as regards electrical resistance and power of ignition which had been searched for for nearly 30 years.

The composition of the wire and arrangement of the priming being thus determined, the only other points remaining were the thickness and length of the wire bridge and the minimum current required to fire it.

On this point there was a divergence of views between the Navy and the Submarine Mining Service; the former wished their apparatus to be readily portable, and therefore desired a small light battery, while they attached little importance to testing arrangements. The Engineers, on the other hand, working from fixed centres, were not seriously inconvenienced by a large battery, and attached considerable importance to obtaining accurate tests of the mine system. The Navy therefore adopted for their detonators as fine a wire as possible, weighing about 0·25 grains per yard. The Submarine Miners adopted a considerably heavier wire of 1·55 grains per yard and ·003″ in diameter, with a bridge ·25″ long and having an electrical resistance of ·3 to ·35 ohms. This could without heating take a current not exceeding ·3 ampères, but required 2 ampères to fire with certainty. For land service, whose requirements lay between the two extremes, an intermediate bridge was adopted of wire ·0014″ in diameter, weighing 0·45 grains per yard, with a resistance of 1·05 ohms. The addition of fulminate of mercury to the original fuzes was made by adding a metal shank to the body of the fuze and filling this with fulminate. Holes were then cut in one disc of the priming charge, of just the size to take the shank of the detonator, thus ensuring good contact between the latter and the primer.

In 1896 the dimensions of these holes, which had varied a little with alterations of manufacture, were standardized for all services, so that any detonator would fit the perforation of any primer.

To ensure the identification of detonators with bridges of different wire a system of colours was adopted for the body of the fuze or detonator—yellow for naval, white for land, blue for submarine mining. The head of low-tension detonators was white, that of high-tension black, the shank was painted red.

Detonators require careful handling, and after one or two accidents with service detonators while instructing beginners, special detonators were provided for drill purposes. At first these were made by extracting the detonating composition from service detonators, a delicate operation which was usually performed by the Instructor himself! Later special drill detonators were manufactured by omitting the composition.

Size of Charges.

The very careful experiments as to the size of charges led to the adoption of the following weights :—

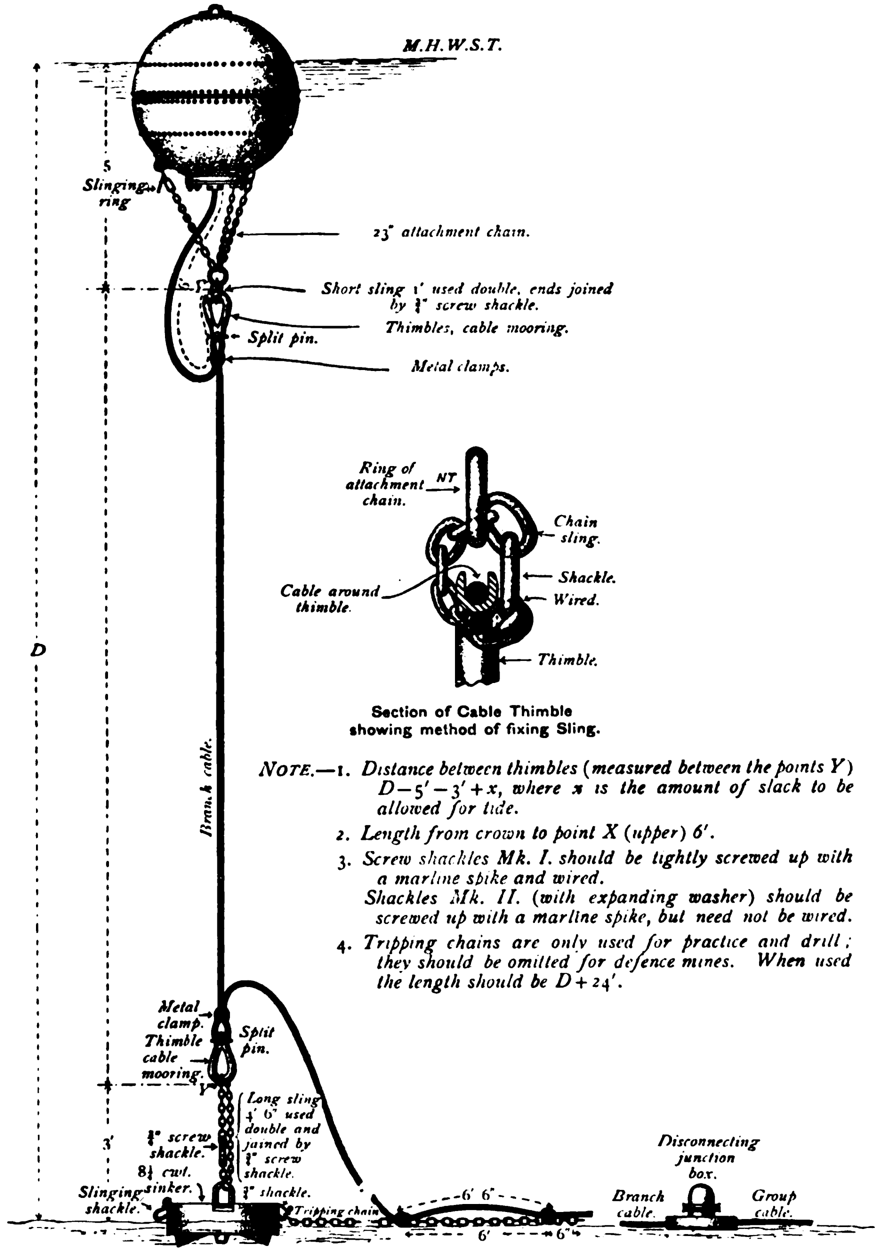
The minimum charge required to seriously damage an iron ship if exploded in close contact was 50 lbs., but as it was probable that the blow of the ship would cause the mine to recoil a short distance from the side, a weight of 100 lbs. of guncotton was adopted as the standard size for contact mines.

For mines to be fired by observation under a considerable head of water a weight of 250 lbs. was adopted for depths not exceeding 36′, and a weight of 500 lbs. for depths not exceeding 60′. Both of these were laid on the bottom, but if the depth of water in the channel exceeded this amount the mine had to be made buoyant, and was then moored at a depth of 48′ from the surface.

Mine Cases.

In the days of gunpowder charges it was very necessary, in order to develop the full effect of the charge, to pack the powder tightly in a stout iron case, and any air space inside the case was prohibited. The case was in the form of a cylinder with an opening at one end, through which the charge could be inserted. The cylinder was made buoyant by being placed in a wooden jacket. This form was retained for all contact mines loaded with guncotton, but it was found that as long as the charge was packed tightly round the primer an air space

100-LB. E.C. MINE, CONNECTED UP AND LAID OUT ON FORK SYSTEM.



Section of Cable Thimble showing method of fixing Sling.

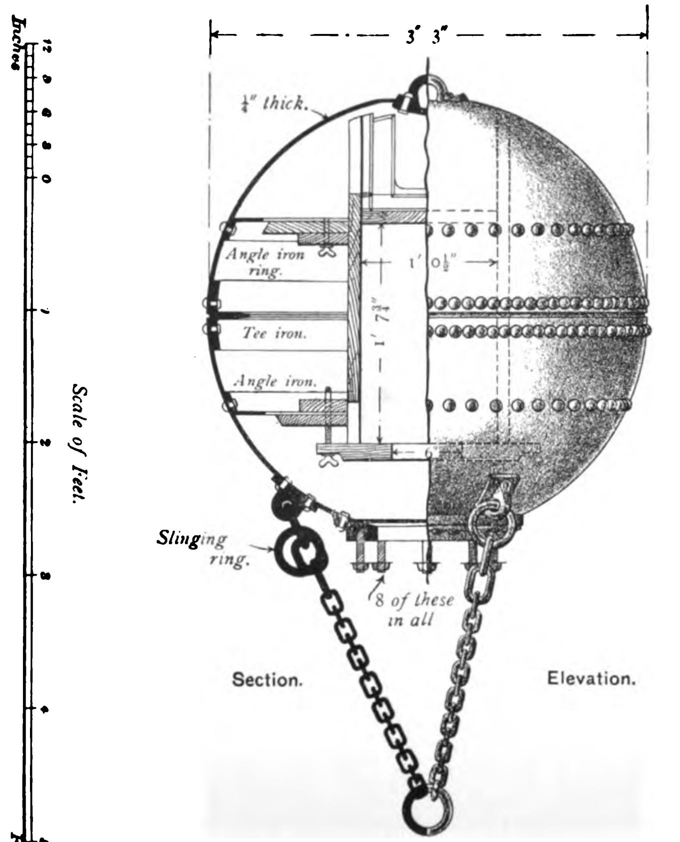
NOTE.—1. *Distance between thimbles (measured between the points Y) $D-5'-3'+x$, where x is the amount of slack to be allowed for tide.*

2. *Length from crown to point X (upper) 6'.*

3. *Screw shackles Mk. I. should be tightly screwed up with a marline spike and wired.*
Shackles Mk. II. (with expanding washer) should be screwed up with a marline spike, but need not be wired.

4. *Tripping chains are only used for practice and drill; they should be omitted for defence mines. When used the length should be $D+24'$.*

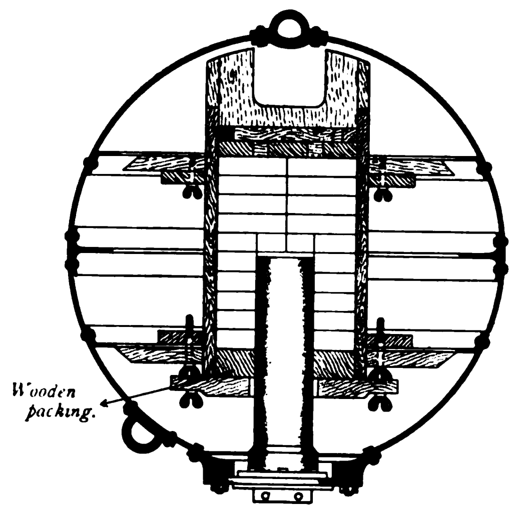
MINE CASES, SUBMARINE MINING, BUOYANT, SPHERICAL, 100-LB. MARK III.



MARK III.

LOADING A MINE CASE, SUBMARINE MINING, BUOYANT, SPHERICAL, 100-LB.

Total weight of charge—109 *lbs.* 11 *oz.*
91 *lbs.* 7 *oz. guncotton and* 18 *lbs.* 4 *oz. water.*



Section of Mark III. Mine Case showing Loading.

did not affect the efficiency of guncotton, so the mines for the larger observation charges were made with an air space in order that they could be used as buoyant mines. They were kept on the bottom, if so required, by lashing to them a heavy weight or "sinker."

The use of wooden jackets was found to be objectionable, as they were liable to get water-logged, and numerous experiments were made with new patterns, consisting of a heavy base, to which the charge and circuit closer was attached, and a domed or pear-shaped cover to exclude the water and form an air chamber. None had been finally adopted when the outbreak of the Russo-Turkish War produced one of our periodical war scares, and Lieut. Bucknill, who was then inspecting stores at Woolwich, introduced the pear-shaped mine without further trial. In these the charge was packed on a deck in the mine, while the circuit closer and primer were packed on a base which also closed the lower opening of the mine case.

These proved very good mines, as their shape made them float well in a strong tide, and they were very buoyant. Their defects were some weakness against countermining and indifferent arrangements for securing the charge. They remained in the service till its abolition.

The next step was the construction of mines of a spherical shape. This was evidently the strongest which could be adopted, but at first manufacturing difficulties intervened. When these were surmounted, the shape was finally adopted, with the charge packed into a wooden box fitted inside the case, and an improved "apparatus"; the only important change made subsequently was the substitution of a steel framework for the wooden box which contained the charge.

This shape was supplied for charges of 50 lbs., 100 lbs., or 500 lbs.

The ground mines remained cylindrical throughout the duration of the service, but the early patterns were lined with a layer of cement about 1883, partly to add weight and partly to give strength against countermining. The latest pattern had no cement lining, but weight was given by heavy castings forming the end of each cylinder.

The early patterns of mine cases differed from the later ones in the shape of the opening through which the charge was loaded, and into which the apparatus containing the primer and testing arrangement was inserted. It was very important that this opening should be closed in such a way as to be watertight, or the case would fill and sink. At first both the mouthpiece and apparatus were made with recesses fitting into one another and pressed together by a screw collar, but later flat surfaces were turned on both, a washer inserted, and the joint made by bolts and nuts. Paraffined leather washers well greased eventually superseded all others. The size of the opening was at the same time increased from 6″ to 9″.

It is difficult to realize the early difficulties connected with a detail such as this, due to want of accuracy in manufacture and want of training in the *personnel*. As Colonel Malcolm writes: "A rule of thumb seemed to establish itself, and things by degrees, as the merely experimental work was left and definite training took its place, became easy and matter of course that at first were most difficult to do."

Method of Mooring.

The method of mooring the mine and the method of attaching the mine to the mooring were also details which gave a lot of trouble.

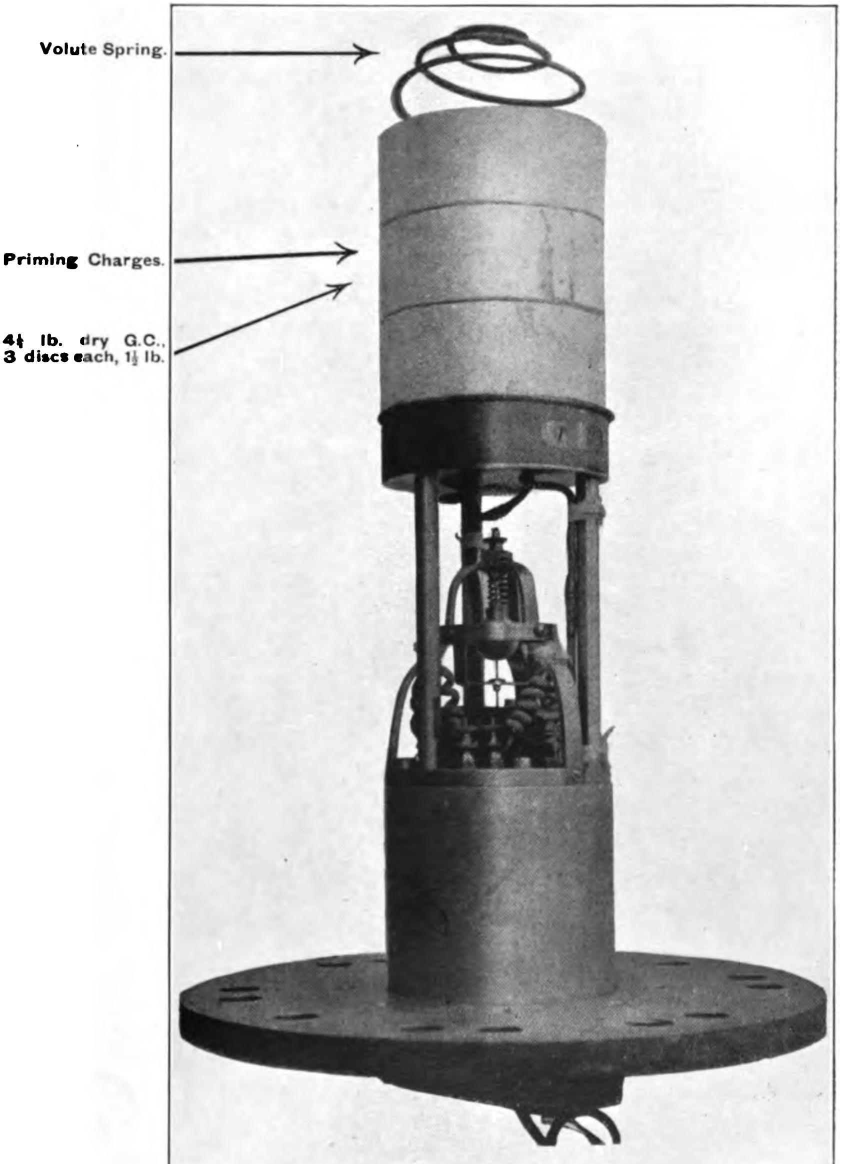
For the mooring itself it was obvious that a heavy weight or "sinker" must be used in preference to an anchor, but even with this it was certain that a floating mine in a tideway would be carried some distance away from its mooring and also a greater distance below the surface than when it was floating straight over its sinker; the larger the mine and the greater the depth, the greater would be the displacement; on the other hand, the greater the buoyancy, the greater the resistance of the mine to the lateral displacement. Also some weight came on the mine from the mooring, and this required some buoyancy to support it; so that with a single mooring the best results were obtained with a small (and consequently light) and very buoyant mine case. On the other hand, increased buoyancy required heavy sinkers and strong moorings.

To avoid the inconveniences of a single mooring, double moorings were tried in the early days, and the experiment was repeated in the eighties, but this form of mooring necessarily requires two sinkers, which have to be laid very exactly a certain distance apart, an operation which proved very difficult to effect in varying conditions of wind and weather. So the single mooring was finally adopted in the form of a 2″ steel wire rope. At first the sinkers weighed 7 cwts. in air, and this was sufficient for the early contact mines with wooden jackets; but as the buoyancy increased this weight was increased to 8¼ cwts. in air (7 cwts. in water), with a larger sinker of 11¼ cwts. for use with the large spherical 500-lb. mines and the later marks of 100-lb. buoyant. These latter had finally a buoyancy loaded of about 300 lbs., the pear-shaped only about half this amount.

About 1893 an important change was made by the introduction of the Duke-Penrose mooring thimble. It had long been thought that the armouring of the cable, which stood a breaking strain of 7 tons, should be used to moor the mine, but repeated experiment by Capt. Tyler and others failed to produce a practicable method till Q.M.S. Duke designed his thimble. This was a large thimble about 9″ long, with a deep recess all round the outside, in which the cable was placed, and the shape of the point of the thimble so arranged that the two parts of the cable crossed one another and were locked in position by a shackle pin and lashing. The loop of the thimble was fastened to the mine or sinker by a loop of chain. This method, with some modifications suggested by Major Penrose, was a decided

PRIMED APPARATUS.

APPS. P. and C.C. MARK VII. (Envelope Removed).



success and gradually superseded the wire rope, with a consequent saving of much complication in preparing and laying the mines.

A very ingenious system of mooring was designed by Lieut. R. M. Ruck about 1881 on the "rise-and-fall" principle. In this system each mine was connected to a counterpoise which sank as the tide rose, letting the mine rise. This was intended for channels with a large rise and fall, but the necessary complication prevented the adoption of this system.

The connection of the mooring to the mine was at first by a sort of tripod cage, but this soon gave way to attachment chains with two or three legs fastened to the mine and the ends brought to a large ring, to which the mooring was attached. This form proved well adapted to stand the continuous movement in a tideway. The connection between the mooring and the attachment chain was by a shackle, and this gave more trouble than all the rest put together.

It may seem at first sight that such details were trivial and easily settled, but it must be remembered that the mines had to live and work in a medium which is much less amenable than the air. People are so accustomed to living in air that they forget the atmosphere has weight until it takes the form of a gale, and even that is kept out by shutting the window. But if anyone tried to do any of the ordinary operations of life under water, they would at once be met with an entirely different set of conditions.

And so it was with shackles. On dry land it seems that the ordinary form of shackle—a bent bow of metal in the form of a hoop joined at the ends by a bar or pin—will suffice to hold any weight that the metal will stand; but under water, however the shackle was closed, it seemed that sooner or later it *would* work loose, and even screw shackles with the pin screwed hard home with a large marline spike became unscrewed. This was not understood at first, and hardly believed, till an experiment was made on the deck of the *Hood*. A weight corresponding to the buoyancy of a mine was suspended by a mooring line and shackle, and a sapper detailed to reproduce the swaying motion of a mine in the water. After an hour or two it was found that the shackle became *unscrewed*.

Capt. R. M. Ruck met the difficulty by a very ingenious shackle, in which the pin could be put in place with the fingers, and which automatically locked when any strain was on, while it was prevented from undoing when there was no strain by an india-rubber pad. These worked excellently when well made, but when obtained in large quantities had to be very carefully gauged. Also the india-rubber perished with use.

After about 10 years of these shackles an improved form of screw shackle was suggested by Major Dean, of the Militia. This had a fibre washer under the head of the pin which expanded when wet and locked the pin in position.

But the problem was finally solved in the Duke-Penrose thimble by the use of loops of chain. The ends of these loops were fastened by a shackle, but the latter had only half the strain and the swaying movement was taken up by the chain.

CABLE.

The electric cables were naturally the subject of much trial and experiment. They consisted of a "core" or cores covered with some form of protection. The core was made up of a copper wire or wires, surrounded by a coating of india-rubber or other insulating material. The copper wire was 7-stranded, each strand tinned to withstand the action of the rubber, which has an injurious effect on pure copper. The rubber was in three layers: first a layer of pure rubber (next to the copper), then a separator, and then a layer of vulcanized rubber. The latter was the harder of the three and kept the remainder from the action of the water; the separator kept the sulphur in the outer layer from working down through the pure layer and attacking the copper. The core was usually covered with a layer of felt or tape at the time of manufacture to prevent the coils from sticking together.

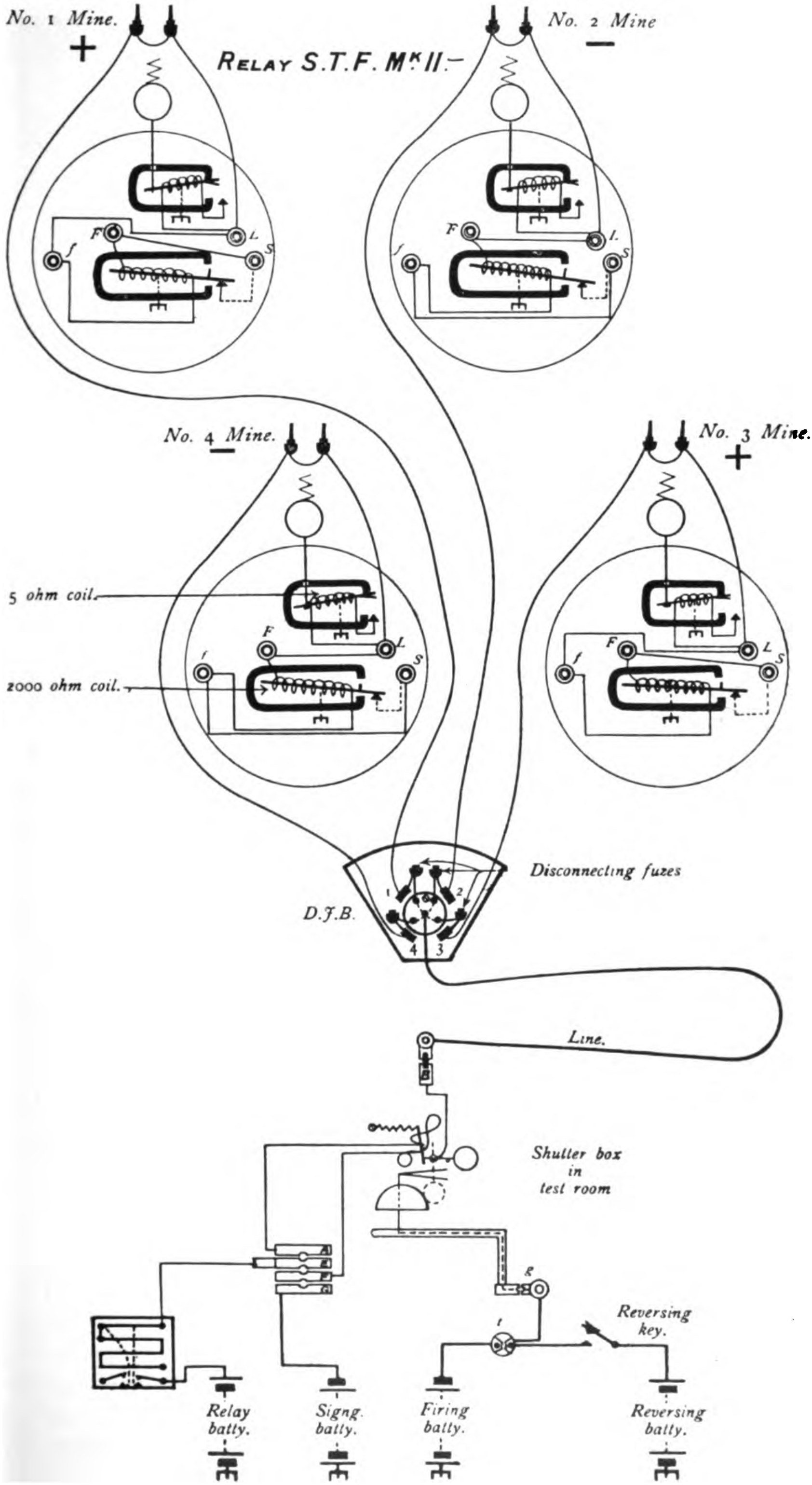
In a single core cable, one such core was surrounded first with a padding of hemp, then with a sheathing of iron or steel wires, and then with an outer serving to keep the armouring in place. All these details were gradually improved, and finally both the inner and outer hemp layers were braided on. The armouring wires were a difficulty for some time; in the early days they were so stiff that the cable could hardly be handled, then they were made of a soft wrought iron, and finally of a fine steel. The latter brought its own difficulties, as most remarkable breaks of continuity occurred with the core of such cable. After long and patient investigation this was traced to the springiness of the armouring causing intermittent expansion and contraction of the copper core, with the result that an elbow was formed and a break soon followed. It was remedied by much increasing the thickness of the inner padding and laying up the core with two dummy cores of hemp.

JOINTS AND CROWNS.

To connect the cable to the mine or to another cable it was necessary to joint first the copper wire, then the insulation, and finally the armouring.

To connect the copper wires they were at first always soldered, a method still used by electricians for most land work. But this was very difficult to effect on a boat, especially in bad weather, and after much trial it was found sufficient to clean the ends carefully and twist them tightly together. The joint so made was then covered with india-rubber layers, the layers being stuck together with india-rubber

ELECTRICAL CONNECTIONS OF A GROUP OF E.C. MINES.



solution. Great care was necessary to make the layers of india-rubber stick to the ends of the insulation, and to ensure thorough protection a piece of india-rubber tubing previously placed over one core was slipped over the joint and securely tied in position. At first bad joints were frequent, but careful attention to details produced an improvement, until at last every member of the Submarine Mining Service was able to make a reliable joint with certainty. As every mine required three such joints on an average several hundred had to be made in the course of a long day's work, but there were very few failures. It is also noteworthy that some joints made in this manner were kept under water for nine years, and found at the end of this time to be in perfect condition.

The connecting of the armouring was sometimes done by a system of splicing, but this was replaced by a system of connecting and junction boxes. For use with these the end of the cable prior to jointing was prepared with a "crown" formed by making a knob of spun yarn about a foot from the end, bending back the ends of the armouring wires over this knob, and lashing them with spun yarn to form a "grip." For a connecting box the grips were held between the two halves of a cast-iron box, with the crowns inside and the ends of the cores connected by a joint. The two halves were screwed together by bolts and nuts, gripping the cable. The joint was thus protected by the box, and the crowns prevented the cable being dragged out. A similar arrangement was made at the mouth of a mine to grip the cable, and a dome or recess was provided to hold the joint. When separate moorings were used the cable was fastened to the mooring at intervals with spun yarn stops to protect it from mechanical injury.

A tripping chain was added to lift the sinker, one end shackled to the latter, and the other lashed along the cable sufficiently far away to allow of the end being taken inboard. With the cable mooring thimbles it was found possible to lift the sinkers by the cable, a further simplification of gear and stores.

Ground mines required no mooring, but they had two-legged attachment chains for the purpose of slinging and for the attachment of the tripping chain. In the early days ground mines rested on saddle-shaped sinkers, but when the mine cases were cement-lined the sinkers became unnecessary.

APPARATUS AND RELAY.

The "apparatus" or works of the mine consisted primarily of a base or lid of cast iron, which closed the loading hole through which the charge had been inserted. This opening was at the bottom in buoyant mines; at the end in cylindrical mines. The base was a circular disc of metal 15″ in diameter and pierced with eight holes, to fit a similar number of bolts which projected from the mine case.

On the inner side of the base was an envelope shaped like an elongated top hat, and inside this envelope was a three-legged cage of metal supporting a gallery or disc of wood, which held the detonators in place and on which rested the primer of dry guncotton. The latter was kept in place by a spring placed on the top, which pressed against the inside of the envelope. The cage served to lash the leads from the detonators and also held in place the electrical apparatus or relay. This latter varied according to the class of mine, and will be better understood when the testing arrangements have been described. The main object of the cage however was to get the priming charge well up into the centre of the mine.

In the first apparatus two leads similar to the core of the cable were fixed in a metal insulating plug, which in its turn was placed in a recess in the base and held in place by a screw collar, a washer being placed in the recess to make the joint watertight. The leads were at first held in this plug by a molten composition made of gutta-percha and pitch, which was poured between two india-rubber discs into the body of the plug, and the top was then closed by a gland and gland-nut, which compressed the composition round the wires. This very unpleasant operation lasted till after 1880, but proved uncertain. Soon after that date it was found that by placing small puddings on the leads of india-rubber tape and compressing these puddings between the body and gland, a better joint could be made.

But a still greater improvement was made in the new apparatus by forming in the base itself a small recess for each lead, with gland and gland-nut, and the operation was still further simplified by the issue of leads with puddings ready cast in place at 3′ interval. At one time there was a fear that water entering the lead at the outside joint would creep up between the wires and so enter the apparatus, and to meet this a portion of the wires inside the pudding used to be soldered. The proper remedy was to make good joints outside, and once this was done it was unnecessary to solder at all.

Methods of Firing Mines.

It has already been explained that mines can be fired on two systems—by observation and by circuit closer. The former is the simpler; all that is required is to connect the mine circuit to earth at the mine end and to connect it in the observing station to the firing battery through a key which is under the control of the observer; when the observer wishes to fire he has only to press the key. If the moment of firing is ascertained by buoys marking the ends of the line of two or more mines, nothing further is required, but in the Watkin position finder, introduced about 1885, the attacking vessel was watched through a telescope, and the latter so mounted that as the telescope moved a pointer followed the course of the vessel on a chart in the observing station. On this chart were placed contact pieces representing the mines, and the circuit was so arranged that when the pointer made contact on one of these pieces the corresponding mine was fired. This proved very efficient, and a simple method was devised of practising the operation by laying dormant buoys in the positions of the observation mines. These buoys were moored with explosive links, and when fired, the buoys came rapidly to the surface alongside the target, and the accuracy of the shot would be determined.

The other method of firing was not quite so simple. It was necessary to provide in each mine a break in the electrical circuit, so that the latter was not connected to earth till the mine had been struck by a passing ship. It was also necessary to keep the firing battery disconnected on shore till the last moment, not only to keep the battery from being run down through a leaky cable, but to prevent the mine firing if struck by a friendly ship. A special piece of apparatus called a shutter box was devised for this purpose.

The instrument in the mine, which was called a circuit closer, consisted in its simplest form of a heavy metal knob on the end of a thin spindle. When the mine was struck the knob vibrated, and so closed a circuit between the knob itself and some flat springs placed round it, or it could be arranged to disconnect a circuit, in either case producing a signal on shore.

This form was improved by Mathieson by substituting for the stiff spindle a helical spring, thus giving greater sensitiveness to the apparatus and greater capacity of adjustment. It should be noted that it was important that the circuit closer should not signal for wave action, and should signal for a grazing blow by a comparatively small vessel.

The next step was a design by Bucknill, in which the bell and spring were made much smaller and hung from a cage; a silk thread was placed down the centre of the spring and bell, fastened at the top to an adjusting screw, and at the bottom to the detent of a small piece of clockwork. On the mine being struck the bell swung sideways, carrying the silk with it, which pulled the detent, starting the clockwork. The latter completed an electrical circuit, which ran for a few seconds, amply sufficient for the operator to fire the mine, and then disconnected the circuit if the mine had not been fired.

Colonel Armstrong substituted for the clockwork an electro-magnet of low resistance, with a core or armature pivoted in the centre, and so arranged that the outer end could lie in contact with one of two stops. Normally, the end lay against the upper stop, in which case there was no circuit through the electro-magnet. The end of the silk was connected to the inner end of the armature, and when the ball was displaced by a blow, the inner end was raised and the outer brought in contact with the lower stop. This completed a circuit through the coil, through which the mine could be fired. If it was wished not to fire, a weak current of opposite direction was sent through the coil, the armature was magnetized, and was repelled by a permanent magnet, which formed part of the apparatus, till contact ceased with the stop and the mine became safe. This was called "reversing" the mine.

This little piece of apparatus was the subject of considerable experiment to determine the best form of all the parts, and it was found necessary to permanently stretch the silk and take other precautions. If this was done it acted very well, and its action was frequently tested by bumping the mines and firing their drill detonators.

There was no passage for electricity through a circuit closer until a mine was bumped, so that no test of the electrical condition could be obtained with this arrangement alone.

In the early forms of mine it was not generally recognized as an advantage to fire a mine by circuit closer only, and mines were arranged so that they could be fired by will at any moment. A high-tension detonator was used, which had a comparatively high resistance, and the contact disc was arranged as an alternative path. A steady weak current was kept going through the mine and through a signalling apparatus on shore, and the latter was so arranged that the action of the contact disc broke the circuit, and the firing apparatus was then automatically switched on and the mine fired, or the firing arrangement could be switched on at the will of the operator.

It is obvious that such an arrangement required a separate cable from shore for each mine, while with the simple circuit closer described above and low-tension currents, any number of mines could be connected to one cable, and only the one which was struck would fire. This proved one of the main advantages of the C.C. system, giving an economy of cable and of connections in the firing room, with no risk that the operator could fire the wrong mine.

Methods of Testing Mines.

With the high-tension detonator it was always possible to pass some current through the mine, and this was combined with a system of earth plates to give an actual test of the existence of the mine itself.

It is well known that two dissimilar metals immersed in liquid will produce an electric current in an outside circuit, and that the amount of this current will vary with the metals.

To utilize this the earth connection at the mine terminated in a carbon plate, and the earth on shore was made by an iron wire rope. On connecting these through a galvanometer, a definite deflection was obtained. If the mine was water-logged or if the cable was so damaged as to expose the copper core, the combination would be different and the galvanometer deflection would be varied. To check this a series of earths was provided in a bucket in the test room.

It is recorded that on one occasion a tester located iron at the mine end, and it was subsequently found that a ship's anchor and cable was foul of the mine! But the more flippant of the younger generation of Submarine Miners used to say that only Armstrong himself could carry out a sea-cell test, and even he did not entirely understand it.

With the circuit closer and low-tension detonators there is no passage through the mine at all, so Armstrong arranged a resistance coil of 2,000 ohms, so connected as to bridge or short-circuit the C.C. This resistance was too high to materially affect the action of the C.C., while it enabled a definite measurement to be made of the resistance of a mine.

But this was shortly afterwards superseded by the introduction by Armstrong of the polarized relay, usually called the "wooden" relay, because the various terminals and parts were mounted on a short wooden cylinder. The essential part was an electro-magnet with two coils of resistances of 2,000 ohms and 5 ohms wound on the same frame. The core or armature of this electro-magnet was pivoted at the centre, and free to move a short way round the pivot. The coils and armature were fixed in a vertical position in the wood, and the ends of the armature which projected from the coil were "polarized" by being placed between the poles of a pair of horseshoe permanent magnets fixed to the top and bottom of the wooden frame. The movement of the armature was further limited by two stops on the top.

Both ends of each coil were brought to terminals on the top, and these terminals and the stops could be connected in numerous combinations to one another or by a fine wire to the armature.

This was originally used with the system of retardation firing described in the 1880 manual, but it gradually extended to other classes of mines.

Very many combinations were possible with this arrangement; a few may be described.

In contact mines, as used in the later stages, the stops were so adjusted that the armature normally lay in contact with the left stop, which was connected to earth. The cable from the shore was connected through the detonators to one end of the 2,000-ohm coil, the fine wire of the armature to the other. The circuit closer was connected in divided circuit with the relay. On passing a current through the circuit so arranged, the armature was magnetized and either attracted or repelled by the permanent magnets, according to the direction of the current. If repelled it tried to leave the stop and broke the circuit; the magnetization then ceased, and the armature dropped back against the stop. These series of operations were repeated with great rapidity on the same principle as an ordinary trembling bell. At first the only means of detecting this action was by the galvanometer, but the introduction of the telephone provided an instrument specially adapted for detecting such changes, and the effect on a telephone in the shore portion of the circuit was the production of a musical note or "buzz." One of the earliest telephones introduced into England was tried for this purpose at Pembroke Dock by Lieuts. R. M. Ruck and C. Penrose in 1878.

The buzzing effect did not commence till a certain strength of testing current was applied, and in practice it was customary to increase the size of the testing battery, cell by cell, by a simple arrangement of plugs, till a point was reached when the armature buzzed. The mine was then recorded as "buzzed 7 cells," and this, coupled with a measurement of the resistance, gave an unmistakable test of the presence of the mine.

It has been said above that any number of E.C. mines could be connected to one cable, but practical considerations finally reduced this number to four. Various suggestions were made to obtain a test of each mine of the four, but finally arrangements were made to test two of them with a positive current and two of them with a negative, and it was then comparatively easy for an experienced tester to say if both mines of a kind were buzzing correctly.

Another use of the wooden relay was in the end mine of a line of mines. In this case it was important to be able to fire the whole at any moment, so the circuit had to be a low-resistance one. Both coils of the wooden relay were used. The 2,000-ohm coil was connected so that it was always in the circuit; the 5-ohm. coil, with the armature and stop in circuit with it, were connected in parallel with the 2,000. A positive current of suitable strength caused the armature to buzz on the stop as described above, but in this case the 2,000-ohm coil was always in circuit, and as the battery power was increased, a point was reached where the current through the 2,000-ohm. coil held the armature away from the stop, and the buzz stopped. This used to be recorded "buzz 3 to 6 cells, armature over 7 cells." In addition to the buzz the deflection was noted on a galvanometer. With the system in good order, the deflection when the armature was over should be small; a large deflection indicated either a leaky cable or a wet primer, a fault to which ground mines were especially liable on account of the pressure of the water.

Although the bulk of contact mines were arranged in groups, there were some advantages in combining the contact and observation system, and observation mines with circuit closers were retained in the defences till 1886.

The relays in these were so arranged that 7 cells positive caused the relay in the circuit closer to buzz, while 7 cells negative crossed the armiture over and brought in the 5-ohm. coil, with a big deflection on the galvanometer.

The firing current, which was negative, either fired the mine through the circuit closer or crossed the armature over and then fired through the 5-ohm. coil.

There was a further variety of the connections for a dormant mine and for the retardation firing referred to above.

On the introduction of the improved form of circuit closer, the essential points of the wooden relay were reproduced in an improved form and fixed below the cage, which carried the inertia ball, one armature then serving for both circuit closing and test. But this proved inconvenient in practice, and on the suggestion of Lieut. R. M. Ruck a separate 5-ohm. coil, armature, and permanent magnet was provided for use with the circuit closer, with a 2,000-ohm. coil, armature, etc., for testing purposes.

The wooden relay continued to be used for all observation mines until about 1898, when a similar arrangement on a brass base was introduced for lines of mines, which was the only system other than E.C. mines which had survived the ordeal of practical trial.

Arrangements in the Firing Station.

The essential features of the firing station were the batteries for firing the mines and testing the system, the shutter apparatus, and the firing and testing instruments. The first form of firing battery adopted in 1870 was the Walker type, a combination of zinc and carbon elements immersed in dilute sulphuric acid. As there was considerable local action, the plates were attached to a frame, and by a lever could all be lowered into the liquid at the time the mines were made active.

The Post Office form of Daniell's battery was used for testing, and also with the shutter boxes and the Leclanché battery for telegraph communication.

In 1875 the Walker batteries were converted into Leclanchés by a change of liquid and the addition of agglomerate round the carbon plates, while a few years later the agglomerate took the form of blocks held in place by india-rubber bands. The Leclanché also replaced the Daniell for testing and other purposes, but being somewhat inconstant could not be used for signalling. As the Leclanché cell is more powerful than a Daniell, there was a risk with a short cable of firing a detonator with a testing current; to prevent this each cell of the testing pattern of Lelanché was crippled by the addition of a resistance of 2 ohms. to the zinc rod of each cell. The Daniell's battery was also improved and a special type introduced.

The following is a complete list of batteries in a test room :—

The *firing* battery was usually of 100 cells of the special pattern firing Leclanché, but a larger number could be used if required.

The *reversing* battery was four cells of the special raised resistance Leclanché.

The *test* battery used for balancing resistance was two cells of the R.R. Leclanché.

The *relay* battery for relay tests was 16 cells, R.R. Leclanché, so arranged that any less number could be used.

There was also a *standard* battery of two cells to give a standard deflection on the galvanometer, to which the rest could be compared.

There was a *reddening* battery of two firing cells to test very low resistances, such as the contacts of the shutter box by the heating of a wire bridge placed in the circuit.

There was one *signalling* battery of three cells for each shutter box and one battery spare.

These were subject to some changes from time to time, but the above were fixed about 1885, and remained without serious change for nearly 20 years.

The shutter apparatus was one of the earliest stores designed by the Torpedo Committee. Its use was threefold—first, to give an unmistakable signal when the circuit closer of a mine was worked; secondly, to disconnect the signalling battery; and thirdly, to switch in the circuit of the firing battery.

At first the alarm was made by firing a fuze, but about 1875 a bell was substituted and the apparatus took the form familiar to Submarine Miners. It consisted of two short electro-magnets connected by a yoke and with an armature not forming part of the core as in the relay, but so placed with reference to the coils that a current through the electro-magnets would attract the armature and cause it to revolve on a central pivot. The armature normally was in a vertical position, and near the lower end there was a projection or trigger contact which engaged a short horizontal arm. This arm was unequally balanced, and on the other end there was a round disc like a small railway signal. When it was engaged by the armature the arm was in a horizontal position, but when the armature was moved by a current and released the arm, the disc end dropped, struck against a bell, and was held against it by spring clips.

The ends of the coils of the electro-magnet were connected, one end to the armature, the other to a brass plate on the base of the box. The disc or indicator arm was connected by the cable to the mine. The bell was connected through a safety plug to the firing key.

On the base of the box were two other plates, one connected to the testing arrangements, and one to the signalling battery; these were placed one each side of the plate connected to the coils, so that by inserting a peg in a hole between the plates the centre plate could be connected to either the testing or signalling batteries. If the indicator was engaged by the armature the circuit was then completed to the mine.

In the normal conditions of the mine the resistance was about 2,000 ohms, and the signalling current was too small to produce any movement of the shutter armature, but if the circuit closer was worked, the resistance of the mine dropped to 5 ohms or less, and the current through the coils attracted the armature and released the indicator. Immediately this happened the signalling battery, coil, and armature were completely cut off from the mine, while the indicator, as it fell into the spring clips, completed a circuit for the firing or reversing currents.

These apparatus were made up in boxes of seven, each apparatus being independent of the others except that the firing plug was common to all in the box.

The firing arrangements consisted of a firing key and two firing earths. These latter were two lengths of wire rope led to the water or to damp soil, and connected on the firing table to a 2-plate commutator, which could be closed by a plug. A similar commutator was arranged to short-circuit the firing key. The leads from the firing battery were brought, the positive to one side of the earth commutator, the negative first to the firing plug of one of the shutter boxes, then to the firing key, and the other side of the firing key to the firing plugs of the other shutter boxes. The box connected direct to the firing battery was called the "automatic" shutter box, and was used for mines of the old type with the old pattern spring circuit closer. In such mines the contact was momentary and firing had to be immediate, also they did not require reversing. The other boxes could be made automatic by plugging the short-circuit plug on the firing table. The reversing current passed through a key which was placed on a flap at the end of the firing table. The current followed the same track as the firing current.

The testing arrangement consisted of a box of 10,000-ohm coils connected for Wheatstone's bridge test with a sensitive galvanometer, commutators, to which were attached the leads from the test and other batteries, a galvanometer with three coils (2-ohm, 10-ohm, and 1,000-ohm), and a telephone. There were also various plugs, some of them at the end of wandering leads. Some of the points were in permanent connection with one another, others were only connected when plugs were inserted.

The permanent connections were all made by insulated wire arranged with the instruments on the top of a table about 4′ by 3′. All the points were identified by letters, and the leads painted different colours. The reddening, standard, test, and relay batteries were placed on shelves on either side of the test table.

There were at first four earths, one for each class of battery, but these were reduced to two, one for the signalling and reversing batteries, which was kept permanently connected to these batteries, and one for the test and relay batteries, which was connected to a point on the test table.

As an example of the arrangement there was an important permanent circuit from a wandering lead called J through the 3-coil galvanometer and a telephone to the right-hand key of the Wheatstone bridge, and then through the series of resistances in the 10,000-ohm box either to a point H and then to the testing plates of the shutter boxes, or to a plate W on the test table. The test battery was tested by taking deflections on the 2-ohm and 1,000-ohm coil of the 3-coil galvanometer. The instructions for completing the circuit were "J to T, plug X" press key. T was the negative pole of the test battery, X connected W with the positive pole, so the circuit was thereby completed.

There were usually five or six shutter boxes in a test room, and the shutter boxes were fixed on a boarded surface 12′ × 4′, placed above the test table.

The connections from the indicators of the shutter boxes were brought to a series of terminals on the right of the shutter board. The main cables from the minefield came into a similar set of terminals placed a little distance to the right of the board, and cross connections were then made as required between these two sets. This formed a universal commutator and enabled a group of mines to be connected to any shutter according to the nature of their apparatus. Cables from observation mines were not connected to a shutter, but leads were provided across the top of the shutter board to a similar commutator on the left, to which were brought the cables from the observing station.

The maximum number of mines which could be connected to one test room with six shutter boxes was 148 E.C. and 12 lines of mines.

At first a direct connection was provided from the firing battery to the firing plug on the position finder, but about 1887, on the suggestion of Capt. H. E. Tyler, the position finder was connected to a shutter of the automatic shutter box, which saved any risk of damage to the firing battery when the observing station was at some distance from the test room. The firing plug at the position finder was retained, and was not inserted until the observer was following the water line of a hostile ship and it was intended to fire the mines.

A change was made in the shutter board about 1900 by which all mines were normally connected for automatic firing; the standard battery was dispensed with and other circuits simplified.

In some cases minefields were composed only of observation mines; in such cases the firing station was fitted with a small shutter board with one shutter box and test and firing tables.

Whenever a test room was in use a complete series of tests was taken every day, in the course of which the condition of every battery and earth was tested, and also all the lead used in the test room. All mine systems were then tested both by balance and by relay test, and the adjustment of the shutters was checked. If a minefield was laid out, signalling batteries were often left connected to see if any mine was struck by a friendly vessel. Any mines signalled were of course reversed.

It was necessary in connection with the tests of the mines when being laid out to establish a good system of communication between the test room and the men making the joints in the junction-box boats, at first this was effected by a telegraph sounder, but as soon as the telephone was introduced it superseded the sounder. The pattern was the Ader receiver, used both for talking and hearing.

At first also Morse recording instruments were fitted for receipt of orders from higher authorities, but these were also superseded by the telephone.

Vessels and Boats.

The vessels and boats used for submarine mining service may be classified as laying-out vessels, launches, lighters, junction-box boats, and small boats. The last comprised cutters, gigs, and dinghies of usual types; junction-box boats were usually fitted with sails. The lighters first used were old mortar boats of Crimean days, but a good type of iron lighter about 70′ long and 25′ wide was afterwards supplied. It had two large derricks for lifting mines, two good hand crabs, and capacious holds in which mines or sinkers could be stowed. Some were also used for storing main cables, in which case the cables were laid out direct from the lighter.

The launches were at first old 42′ naval pinnaces fitted with a boiler in the well and small twin propellers. They were fairly handy for laying E.C. mines, but their weak point was in raising mines, as they had only a small hand crab. They were only half-decked and were not very seaworthy. They were replaced by a good type of working launch about 50′ on the water line, with steam crab, bow derrick, and fully decked. Such a launch could carry on deck, sling, and lay out a group of E.C. mines, but was best employed for junction-box moorings and group cables, also in picking up and laying dormant buoys, towing junction-box boats, and similar duties. There were also some smaller fast launches for towing, transport of officers, etc.

The first laying-out vessels were lent by the Navy; they were tugs of all descriptions, generally paddle wheel, and were mostly very little adapted for the work. The first specially designed boat was built in 1875 by Messrs. J. & W. Dudgeon, of Millwall, to designs based on recommendations of the Torpedo Committee. This was the beginning of the well-known *Miner* class, some of which survived for 30 years. These were 65′ long, 15′ beam, draught of water 4′ 6″, tonnage 67 tons, and H.P. 30 nominal. They had a good steam winch and small chart house on deck, and were subsequently fitted with a bow derrick. They were all thoroughly overhauled in 1894 or thereabouts, and fitted with a bridge and two side davits. Thus equipped, they were especially fitted for laying E.C. mines, of which they could carry four groups.

The larger laying-out vessels were first introduced in 1885, when the vessels of the Gordon class were started by Colonel Malcolm. These were 80′ long on the water line, with 18′ beam and a tonnage of 100 to 120 tons, and were fitted with single screws and turn-about rudders. The first two built were called the *Medina* and *Solent*, but the former was re-named the *Gordon*. Most of the subsequent vessels were also named after distinguished R.E. officers, especially those who had been interested in the Submarine Mining Service.

Of the Gordon class there were the *Solent*, *Lord Heathfield*, *Burgoyne*, *Victor*. *Empress*, and *Dundas*. Then there followed a rather smaller class, *Sir John Jones*, *Sir Richard Fletcher*, *Sir William Reid*, *Sir Francis Head*, *Sir William Green*, and *General Elliott*, *General Skinner*; and *Napier of Magdala*. Then a rather larger group with numerous variations in detail, the *Sir Charles Pasley*, *Sir Howard Elphinstone*, *Sir Frederick Chapman*, *Sir Henry Harness*, *Sir Lothian Nicholson*, *Sir William Jervois*, *General Stotherd*, and *Armstrong*. Finally ending with two named *Pennar* and *Haslar*, after the neighbourhood of the submarine mining establishments at Pembroke and Gosport. All the above survived to the end of the service.

The larger boats had two masts fitted with mast derricks, in addition to a bow derrick. There was also a large steam crab with horizontal and vertical drums, a big bow joggle or fairlead over which the cable was led when picking up, cleats at suitable intervals down the side, and a slinging rail under the gunwale for attaching flakes of chain or cable. The engines were compounded with twin screws. There was generally an officer's cabin at one end used by the coxswain if no officers were on board, and living accommodation at the other for the crew.

The usual crew was a coxswain, two or three deck hands according to size, two engine drivers and two stokers for the engine room, and a cook who gave a hand on deck on heavy days. A third engine driver was sometimes put on board for the day to attend the steam crab. The larger vessels could carry six or eight groups of E.C. mines, or an equivalent of observation mines, and were capable of working in fairly rough weather.

CHAPTER XIII.

DETAILS OF MINEFIELDS.—DISTANCES OF MINES.—ARRANGEMENT OF MINEFIELDS.—SURVEY OF MINEFIELD.—STORAGE AND PREPARATION IN PEACE.—ORGANIZATION FOR LAYING OUT.—"A BIG DAY."

BEFORE the arrangement of minefields can be understood, two sets of figures must be considered, one the distance at which mines will be certain to put a ship out of action and the best depth to obtain the full effect of the change, the other the distance between mines at which they will be certain not to damage one another. The first set were fixed originally by the early experiments with the Oberon, and may be summed up in the following table :—

Charge of Guncotton.	Maximum Horizontal Distance between Mine and Hull to produce Serious Damage to Engines and Machinery.	Maximum to produce Serious Damage to Hull.	Depth of Charge below Surface.
50 lb.	5′	In contact.	—
100 lb.	10′	Nearly in contact.	—
250 lb.	20′	10′	Up to 36′
500 lb.	30′	15′	36 to 60′ best depth 48′

It will be seen that the 50-lb. mine had to be fired practically in contact, and the 100-lb. so nearly in contact that no margin was left. Both these were used for E.C. mines only. The 250-lb. was the smallest charge used for observation mines, and that only in water not deeper than 36′. The normal size for observation mines was thus 500-lb. There were a few 600-lb. mines formed by cement lining the early 500-lb. buoyant cylindrical cases, but these were used interchangeably with the 500-lb. size.

The distance at which the explosion of a charge would affect the circuit closer of E.C. mines was as under :—

50-lb. charge, safe distance	... ...	75′
100-lb. " " "	... ...	100′
250-lb. " " "	... ...	240′
500-lb. / 600-lb. " " "	... ...	300′

Ground mines were less affected by an explosion than circuit closers, and therefore could be placed a little nearer than the above.

In considering whether a minefield should be composed of E.C. or observation mines, the advantages and disadvantages of the two classes may be considered.

The E.C. has the advantages of:—

(1). Certainty of effective action if fairly struck and certainty of firing independent of fog, rain, or darkness.
(2). Economy of guncotton, only just sufficient being used to put a ship out of action.
(3). Economy of cable; one conductor suffices for four mines.
(4). The personal element is eliminated when firing.

The principal disadvantages are:—

(1). They restrict the navigable channel.
(2). They are more easily destroyed than ground mines.
(3). They are difficult to use in strong tides, or where the rise and fall is considerable.

Observation mines have the advantages of:—

(1). They offer no hindrance to traffic.
(2). They are not readily caught by a sweep or mine catcher hung over the bow of an enemy's ship.
(3). They are independent of tide.
(4). They are not easily damaged.

Their disadvantages are:—

(1). They are useless in fog, thick weather, or darkness (in the absence of electric lights).
(2). They require a large charge of explosive.
(3). Their efficiency depends on two accurate observations—one when laying and one when firing.

Before considering the arrangement of a minefield, it is necessary to consider the method of passing in traffic, whether the channel is to be entirely closed, or whether an unobstructed channel must be left through the minefield, and if so, its position and width.

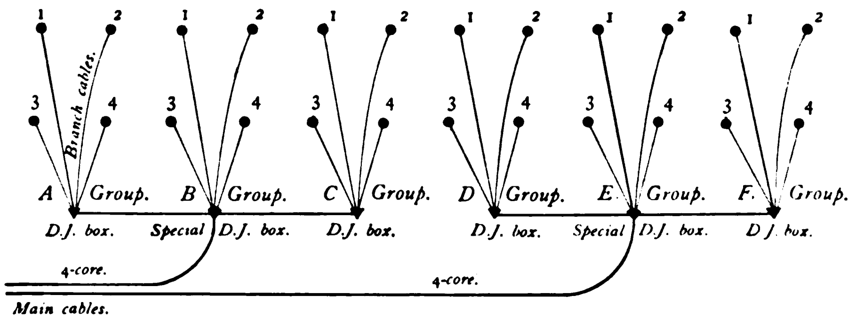
In British ports it was always necessary to have such a channel, and as a rule a width of 200 to 300 yards was found sufficient. Unless the whole width of the entrance was less than 400 yards, it was usually necessary to use both E.C. and observation mines.

As a general rule, also, the position of the minefield in the defence was conditioned by the sites selected for the main batteries and the position of the examination anchorage. It was important that ships sunk by mines should not hinder navigation, so that mines were not

GENERAL ARRANGEMENT OF E.C. GROUPS, SHOWING BRANCH, GROUP, AND MAIN CABLES.

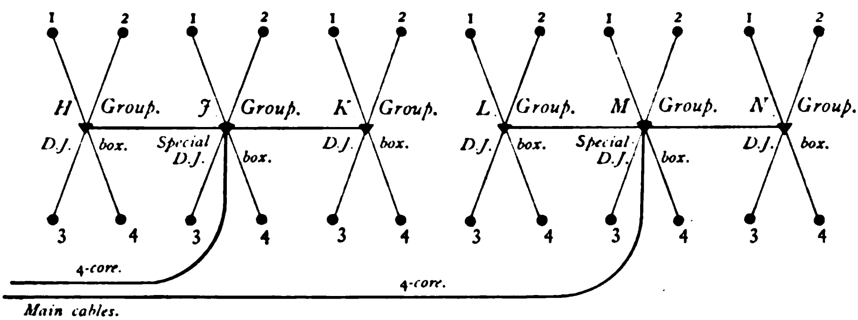
FORK SYSTEM.

FIG. 1

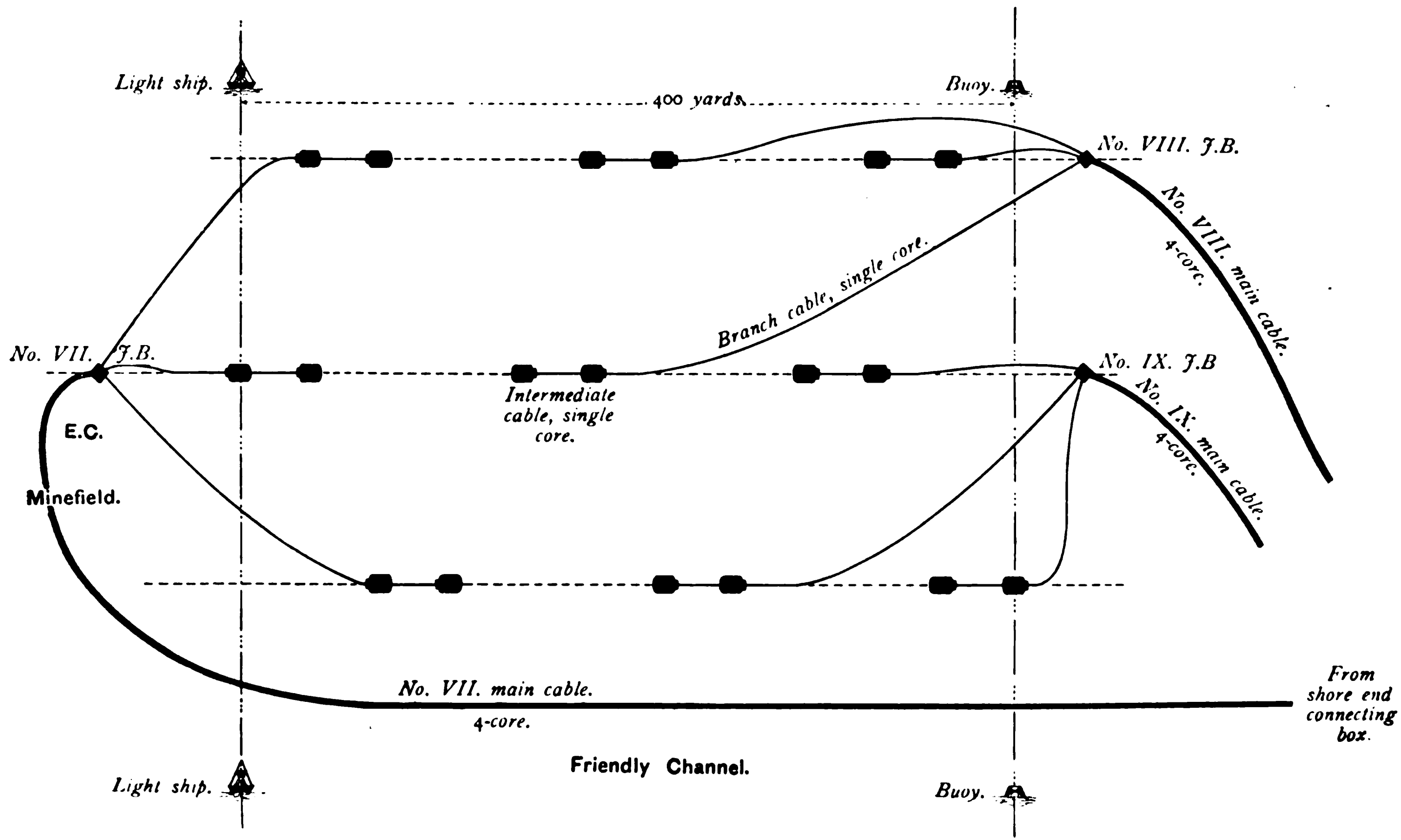


CROSS SYSTEM.

FIG. 2.



GENERAL ARRANGEMENT OF LINES OF 500-LB. MINES, SHOWING INTERMEDIATE, BRANCH, AND MAIN CABLES.



placed in the narrowest part of the approaches, but usually abreast of the main batteries at the rear of the area covered by gun fire. This enabled the system of lights installed for the guns to be used for the observation mines also, and gave a gun defence over the mined area without providing special batteries for the purpose.

The first thing to be done in designing a minefield was to select the position, direction, and size of the friendly channel. This had to be marked by lightships or buoys before the mines could be laid out, and the position of the moorings for these had to be considered with reference to the mine cables.

From the above tables it will be seen that the maximum destructive radius of any observation mine is 30′, so that if mines were used singly, not only would it be very difficult to arrange for them not to damage one another, but there is very little margin for errors of observation. Such mines were therefore arranged in lines of two, three, or even four, all the mines in a line being fired simultaneously. Each line was thus the equivalent of one large mine, but with the charge divided between several cases, and thus spread over a large area. The mines in a line were spaced so that no ships of the class they were designed to meet could be between two mines at the moment of explosion without fatal injury. With 500-lb. mines this space was 100′, so that a vessel with 40′ beam or over would always be within 30′ of one mine or other. The total length of the dangerous area covered by two mines was 160′, or allowing for the beam of a ship, each pair of mines, if laid across the channel, covered a front of 200′. As they had to be 300′ from any neighbouring line, it was necessary, in order to cover the whole channel, to place a series of lines in echelon, one behind the other.

If three parallel lines 100 yards apart are drawn across a channel 300 yards wide, it will be found that six lines of mines placed two on each of the parallel lines can be arranged so as to provide a complete defence of the channel.

With 250-lb. mines the radius is 20′, and the maximum beam of a ship is taken at 20′, so that the distance apart was 60′ and the front covered 120′. These were only used in shallow channels.

The observing stations were placed on the shore abreast of the mines, and if possible at a height above the water not less than $\frac{1}{60}$ of the distance to the furthest mine. If this could not be reached, the mines were laid in lines of three or four mines, to give a greater margin for errors.

The E.C. minefield was arranged on either side of the friendly channel, and as mines could not be less than 100′ apart, and it was desirable to give a margin for inaccuracy of laying, the usual distance between 100-lb. E.C.'s was 150′. The mines were then arranged in six rows across the channel, covering intervals as far as possible, and giving a mine to every 25′ of front.

The position of the mines being determined, they had to be grouped, and the arrangement of the main cables had to be settled. These were multiple cables of 7 or 4-core, the latter being used when possible to avoid exposing too many mines to damage by a single creep. One core in each multiple cable was left spare. The connections between the multiple cable and the cables to the mines were made at a junction box which was attached to a buoy so that it could be readily picked up, and the moorings of the buoy were used for the junction-box boats which lay at the moorings while making joints. In observation mines these buoys were placed on the edge of the friendly channel, and it will be seen that two 4-core cables will suffice for six lines of mines.

With E.C. mines, the first thing was to arrange them in groups of four; this was done in two ways, called the "cross" or the "fork." On the cross system four mines were arranged at the corners of a four-sided figure, 150′ wide and 400′ deep, and the junction box was placed at the intersection of the diagonals. On the fork system the mines were placed on two lines about 200′ apart and covering the intervals, and the box was on a third line about 200′ behind; the cables then took the form of the prongs of a fork, hence the name. The main cables ended in boxes placed either in front or behind the mines, and the main boxes were connected to the group boxes by single-core cables called group cables. A later improvement was to take a 4-core main cable direct to the centre group box of every three groups; the side groups were then connected to the centre box by group cables, a saving of one box and mooring and some cables. The junction box of a group of mines contained arrangements for connecting the various cables, and also a water tight chamber containing a fuze for each mine of the group. These fuzes were made with the same electrical constants as the detonators in the mine, so that they fired simultaneously, thus disconnecting the circuit, and so insulating the broken end of the cable of a mine which had been fired.

The routes of the main cables from the mines to the shore were situated so as to avoid crossing or passing near a ground mine. If this necessitated a sharp turn, a mooring was provided for the cable at the turn, but otherwise they were held in place by their own weight.

Theoretically, these cables should be continuous from the minefield to the test room; in practice it was necessary to lay them in two or three portions called "land" cables, "shore end" cables, and "main" cables.

Land cables were always laid beforehand, and extended to high-water mark, where they ended in a connecting pit. They were laid on sheltered routes and buried to be safe from shell fire. There were generally plenty of spare cores.

The shore end cable, if used, extended from the land pit to beyond low water. If the beach was sand and landing easy, the shore end cables could be dispensed with, but with a rocky beach or a long expanse of shore uncovered at low tide, it was usual to lay out shore cables at leisure with connecting boxes at their ends, either buoyed or connected to chains, which could be readily got hold of. Shore end cables were often doubly armoured.

In the early days two other forms of mine had to be considered. The observation mine with circuit closer could be fired by either method, but combined the defects of both. It was intended to be used in front of the ordinary E.C. minefield. Its one advantage was that the large charge allowed of firing when the circuit closer was some distance from the ship, and would thus defeat any attempt to keep mines at a distance from the ship by torpedo nets or some form of mine catcher. The same advantage was gained by omitting the observation firing and connecting the circuit direct through the mine to the circuit closer. The mines then became large E.C.'s, and could be connected in groups. Some of these groups were often placed in front of the E.C. minefields.

The second form was the dormant mine. This was an ordinary E.C., which when first laid was held down close to its sinker by a short mooring and special link; the latter contained a small charge, which when fired broke the link and disconnected the mooring. The mine then floated up to its proper depth as an ordinary E.C.

At first the mine circuits were so arranged that a single cable was used for each mine, through which the link was fired with a positive current, the mine with a negative. But, later, 3-core cable was substituted for the single core, and so connected that two cores were used for the link circuit. The mines were then quite independent of the links, and could be grouped like ordinary E.C.'s, the links of all the mines of a group being connected and fired in series.

Dormant mines were used in friendly channels, and were released only when fog or mist rendered the observation mine useless, but when released they blocked the channel until relaid.

With the traffic regulations which prevailed when mines were in use, this was inadmissible, and dormant mines were forbidden in 1892.

An important detail of the minefield scheme was the depth at which E.C. mines should be set below the surface.

At first it was thought that they should be visible as little as possible, but the necessity of meeting attack by light draught vessels caused these mines to be placed nearer the surface.

The length of mooring required was determined partly by calculation and partly by experiment.

The formula for the length took the form

$$d + \frac{d}{b} - a,$$

where *d* is the depth at mean high water at the position of the mine, *b* is a constant determined experimentally to allow for the mine being carried away from its sinker by the tide, and *a* is the distance the top of the mine is to be kept below the surface plus the distance from the top of the mine to the ring of the attachment chains.

One other form of mine may be mentioned and that is the "dummy." This is an imitation mine generally made up of old stores and used to deceive the enemy.

Survey of Minefield.

In order to properly regulate the distance between mines and to cut cables to the correct length, it was necessary to make a very careful survey of the position selected for the minefield, both as to shore lines and surroundings.

It was seldom that the naval charts or even the Ordnance Survey maps were sufficient for this purpose, and the survey thus took the form of the compilation of a plan on a scale of $\frac{1}{2500}$ or $\frac{1}{1250}$.

It was usually based on a small triangulation, carried out with a theodolite either from a measured base or from known points, with details filled in by plane table.

In connection with this, the positions of the mines were marked by "alignments," or imaginary lines on shore whose prolongation passed through the position of the mine. These alignments were marked by objects such as rocks, buildings, etc., or by poles, cairns, etc., erected for the purpose.

The simplest method of fixing the position of a mine was by two intersecting alignments, but this was seldom practicable and generally one alignment was used, and the position along this line found for E.C. mines by sextant angle to prominent points on shore, by position finder or by actual measurements. In observation mines fired by position finder the latter was always used to fix the position.

Sometimes the junction-box buoys were laid carefully in this way, and the mines laid by judgment round them.

A datum point or prominent fixed object in the sea was necessary for the position finder, and if no rock, edge of a wharf, or similar object could be found, a pile had to be fixed for this purpose. Its position was carefully surveyed and was usually included in the original triangulation.

The survey completed, careful soundings had to be made at the exact position of each mine. These were taken with a heavy lead and carefully stretched line, and in favourable conditions of weather.

The height of the tide was checked at the time, which involved the previous erection of a tide gauge, and the soundings were corrected to mean high-water ordinary spring tides.

Preparation of Mine Stores.

The minefield being arranged and the survey completed, the next step, assuming the necessary stores were available at the station, was to push on the preparation of these stores as far as possible.

At first, when the mine stores remained in charge of the Ordnance, except during the period of the annual practice, no preliminary preparation was possible, but as R.E. companies were allotted to definite stations and kept there throughout the year, they took charge of their mines and stores.

The first thing started was the permanent loading of the mine cases, first begun about 1883 with ground mines, and gradually extended to all E.C.'s. The mines had to be kept closed up and were carefully weighed annually to see if the charge had retained its weight. Mines were kept marked with group and number.

Then it was found possible to keep the apparatus ready prepared with leads fitted, relay adjusted, and detonators in place. They were numbered and allotted to mines.

The primer could not be kept inserted as it had to be kept under magazine conditions. The junction boxes were also fitted with leads and fuzes and allotted to groups, and the moorings prepared.

Mooring lines when used were cut to length, fitted with thimbles, marked and stored with their mines. Tripping chains were also cut to length, marked, and appropriated.

Of course, mines and apparatus were really interchangeable, but once a mine was fitted with a mooring line it had to go in one definite position, and it was found more convenient to mark all parts from the first and keep them for the particular mine.

Land cables were always laid and sometimes shore end. Main cables were cut to length and in some cases were stowed in cable lighters, from which they were laid direct. Sometimes they were kept laid out with dormant buoys, which were renewed every three months.

Group cables were also cut and appropriated, but only 33 per cent. of the branch cables were kept cut, the remainder being kept in long lengths in the cable tank.

All details required for assembling the gear, embarking and laying, were kept prepared in books for use by the various parties.

Operations Necessary when Laying Out the Defences.

The further operations necessary for laying the mines under war conditions were divided into the following :—

Priming Party.—Making a final inspection of apparatus, inserting dry primer, and issuing primed apparatus to the mine store.

Mine Store Party.—Inserting primed apparatus, putting mines on trucks with mooring lines, etc., if stored in mine store.

Fetching Stores Party.—Bringing up mines, cables, etc., to the connecting up ground, and taking mines and sinkers to pierhead.

Connecting-up Parties.—Connecting cables to mines and arranging mooring.

Pierhead Parties.—Embarking mines on the laying-out vessel.

Laying Parties.—Slinging and laying mines and cables.

Junction-box Boat Parties.—For each junction-box boat.

Test-room Party.—Testing mines and attending to position finder.

Alignment Party.—If any alignments are marked by movable poles.

Crews of Vessels.—The usual strength of a party was 1 N.C.O. and 6 men.

Although all these parties were drilled for rapid work, it was probable that some notice would be given before the mines could be laid out. In such a case the apparatus would be primed and inserted, main cables laid with dormant buoys, branch cables cut, sinkers got to pierhead, and test rooms and observing stations overhauled. All dormant buoys already in use would be fired, cables tested, and buoys relaid. But assuming the worst case that no notice had been received, the various parties worked as follows :—

The *priming parties* worked in specially constructed buildings called priming pits, generally built in a corner of the enclosure and protected from the rest of the buildings by traverses. Only one man worked in a pit, and stringent safety precautions were enforced. As soon as an apparatus was primed it was inserted in the mine by the *mine store party.* The latter worked in the loaded mine store, which was usually about 40′ x 20′, and was fitted with an overhead traveller to lift weights up to 1 ton. An 18″ tramline connected to the general system ran down the centre of the building. When the apparatus was inserted, the mines were lifted and placed one or two on a small truck, with their mooring lines and tripping chains if stored in the mine store. They remained on the truck till lifted off at the pierhead. To facilitate work in the mine store, the mines were stored in the order they were required by the laying-out party, and this order was of course known to the N.C.O. in charge of the party.

The *fetching stores party* had meanwhile been cutting and crowning cables and laying them out on the connecting-up ground. They also removed the loaded trucks from the mine store and brought in empty trucks.

The *connecting-up parties* had to first make the joints between the leads of the apparatus and the cable, then connect the mooring and stopper cable and mooring together, also fasten the end of the tripping chain to the cable. Two to four such parties were usually detailed for this purpose. They left all the gear so stowed on the truck, that the mine could be lifted as a whole and put down on the deck of a vessel. Sufficient parties were employed to keep all the laying-out vessels constantly at work.

The *pierhead parties* took the mines from the connecting-up ground to the pierhead, lifting them off with the pierhead cranes on to the vessel's deck or on to the pier, and sent the empty trucks back to the mine store. One party was required for each crane in use, and there were generally two on a pier.

The *laying-out parties* worked on the vessel's deck assisted by the crew. There were usually two parties, one on each side of the vessel, and their duties were to receive the mines on deck, to sling them in succession, and to lay them out. The loading of the vessel was usually done from the stern, the forward mines being first laid out. E.C. mines were slung on either bow, using the bow and foremost derricks to lift them ; lines of mines required more space than E.C.'s. Slinging was effected with short manilla ropes passed through a ring of the mine or sinker, and with both ends made fast on board. The sinker or mine lay outside the boat against the rubbing streak, and on reaching the position of the mine one end of the rope was let go and the weight slid down into the water. Sufficient cable was slung outboard to enable the weight to reach the bottom, and the end of the cable was then brought in over the bow joggle and ended in a coil. Latterly this coil was placed on a vertical wooden drum, designed by Capt. Organ, of the Coast Battalion, which facilitated paying out, but at first the cable had to be paid out by hand, and in such case some experience was necessary to avoid kinks and fouls. With the early cables with stiff armouring, nasty accidents were often only narrowly avoided, and one man—afterwards Sergt.-Major Bates—was once dragged right under. When the sinker grounded he shook himself free and was picked up. He was greeted by the officer on reaching the deck with the remark "You starred one that time !"

An important feature of the laying was the manœuvring of the vessel to get into the right position. Not only had the alignment and other measurement to be considered, but also the position of the junction-box boat, the side of the vessel on which the mine was slung, and the direction and strength of wind and tide.

The ideal method was that when the mine was let go the vessel would drop down gently near, but not touching, the junction-box boat, and ready, as soon as the cable was passed to the boat, to go ahead to the position of the next mine. The twin screws were freely used to turn the vessel, and the engine-room staff was kept on the alert starting and stopping engines. The whole required a good deal of co-operation on the part of the coxswain, engine-room staff, and N.C.O. in charge of the party, and good results were only obtained with practice. The officer in charge usually stopped on the bridge and looked after the alignments, sextant angles, etc.

The *junction-box boat party* consisted of two men capable of making joints, and one or two boatmen. They all had to have good sea legs, or the movement of a small boat in a seaway was apt to be disturbing. Their duties were to make the necessary joints, to make any connections required when taking tests, to lower away the boxes without fouls, and generally to carry out the orders of the test room.

The disconnecting junction box contained inside a watertight lid a commutator by means of which each mine could be connected to the group cable, and while this lid was open telephonic communication was used to the test room. When the box was closed orders were transmitted by flag signalling. It was necessary to leave everything in good order, and before a boat was allowed to leave its mooring a test of the mines was taken with the box lowered overboard.

The *test-room party* was usually two or three men in the test room, and two men to each position finder, with a signalling party of two men on some prominent point in telephonic connection with the test room. Most of the messages to the minefield were sent by telephone.

With two laying-out vessels, 20 mines might often be laid in the hour, and as three or four tests were required for each mine, the tester had a very busy time, though he had some relaxation while the laying-out vessels were getting their next loads.

The *alignment parties* were usually required to hold up poles or flags in positions marked by pickets or sockets. They communicated with the vessels by flag signalling.

When mines had to be picked up, the order of the operations was reversed, and though it was improbable that the rapid clearing of the minefield could be vital to the defence, the operation was usually done in quick time, as the rapid work was interesting and the parties were anxious to get done. If by any mistake at the junction-box boat, or by action of the tide, two mines or systems were foul, or if a cable broke, a good deal of skill and experience was required to unravel the knots. As a last resource, an axe was supplied, but it was considered rather bad form to use it except in an actual emergency.

The average rate of each individual operation was as follows:—

Priming.—Four to six apparatus an hour for each pit.

Connecting Up.—One party would connect up a group of E.C. in 20 to 25 minutes.

Embarking.—With suitable cranes, four to six groups of E.C. mines could be embarked in 20 to 35 minutes.

Laying.—About eight E.C. mines an hour, sometimes increased to 10 or 12. The rate depended almost entirely on the skill of the coxswain in getting his boat into position.

Raising Mines.—Four to six E.C. mines an hour.

As an example of rapid slinging, two E.C. mines complete have been slung on a launch alongside a lighter in less than three-quarters of a minute from the time the launch came alongside till the order was given to go ahead.

This chapter may be concluded with the narrative of a "big day," taken almost exactly from an actual experience of the writer's. It is selected not as being the best of its class, but as fairly typical of the interworking of the various parties.

It occurred at Gosport in 1895, and was the first big day of a Militia training, and only two days after the Militia had joined the works. For various reasons it was determined to lay 100 mines, divided between the Spithead and Stokes Bay minefields, which necessitated working from two different establishments, while the Spithead minefield was over 3 miles from the submarine mining pier at Fort Blockhouse, which added considerably to the time required to dispose of a load.

The Spithead mines were in actual defence positions, and when laid would have formed a complete defence, except that to comply with peace conditions their moorings were shortened so that E.C. mines were at least 36′ below low water.

The general and special ideas laid down that a state of war existed, and that all possible preparations should be made with a view to the rapid laying of the minefield immediately the order was received. In pursuance of this order, main cables were laid at Spithead, all apparatus was primed and inserted, and some mines and cables were connected up and embarked on the boats. These operations were done the second day the Militia came on the works, and everything was ready to proceed as soon as the orders were given.

At 7 p.m. the same evening the order to lay out the minefield was received, and the following orders which had been prepared in readiness were issued :—

SUBMARINE MINING ORDERS.

Fort Monckton, Gosport, 15th March, 1895.

1. *Work to be done.*—Lay out in quick time at Spithead lines 101 to 112, and 113 to 124, and groups A to L, and at Stokes Bay lines 201 to 212, and groups P, Q, R, S, T.

2. *Steam Boats.*—Steam by 6.30. Alongside pier by 7 a.m.

(*a*). *Pasley.*—Tow out No. 1 Pinnace and *Wild Duck* and *Sappho* if wind fails.

Lay out 11 J.B. buoys and moorings, mines 101 to 112, and A.B. groups all embarked to-day.

Embark at Blockhouse, and lay mines 113 to 124.

Embark at Stokes Bay and lay 201 to 212.

Capt. Hawley in charge, with Lieut. Buckley.

Sergt. Stanton in charge of parties.

(*b*). *Miner.*—Tow out No. 2 Pinnace and hired J.B. boats if wind fails.
Lay out C, D, E, F, G groups embarked to-day.
Embark at Blockhouse and lay out H, J, K, L groups.
Embark at Stokes Bay and lay out P, Q, R groups, and S and T if ordered.
Lieut. Yockney in charge, with Lieut. Sewell.
Sergt. Brook in charge of parties.

(*c*). *Farad* (launch).—Leave as soon as parties arrive with test-room and alignment hands.
Lay out group cables in order CD, AB, EF, relay dormant buoys, and tend J.B. boats as required.
Take in test-room parties when finished.
All buoys at M.J. boxes to be removed, and main cables laid with dormant buoys.
Q.M.S. Brown in charge.

(*d*). *Primrose.*—For O.C.S.M., and as ordered.

3. *Junction-box Boats.*—
No. 1 Pinnace to I., M.J.B., then to III., M.J.B.
No. 2 Pinnace to II., M.J.B., then to IV., M.J.B.
Wild Duck to C, then G.
Sappho to D, then H.
No. 1 hired boat to A, then J.
No. 2 hired boat to B, then K.
No. 3 hired boat to E, then L.
No. 4 hired boat to F.
Hired boats will be at Blockhouse by 6.30.
Buoys at Stokes Bay to be picked up in the following order:—
P, Q, X, MJB, R, S, T.

4. *Shore Parties.*—Connect up H, J, K, L for *Miner*, and 113 to 124 for *Pasley*, and embark.
Then march to Stokes Bay, connect up P, Q, R, 201 to 212, and S and T groups in this order.
Lieut. Mortimer and S.M. Bates in charge.

5. *Test-room and Alignment Parties.*—To go out in *Farad.* Party when finished at Horse Fort to move to Stokes Bay. S.M. Harrison at Horse Fort. Q.M.S. Shearburn at Noman's.

6. *Steam Cranes* at Blockhouse under steam by 8 a.m., at Stokes Bay by 11 a.m.

7. Distribution of parties will be in accordance with Standing Orders.

8. *Parades for R.E.*—
Breakfasts, 6.15 a.m.
Test-room and J.B. parties parade at 6.30 a.m.
Other parties at 6.45 a.m.
Lunch will be taken out for all hands.
Dinners at 6 p.m.

O.C. Militia Division will be good enough to make similar arrangements for the Militia.

(*Signed*) ————— O.C.S.M.

Issued 7 p.m., 14th March.

It will be noticed that both the *Pasley* and *Miner* have rather full loads; the former 11 group moorings and 20 mines, the latter 20 mines. Also that group cables and junction-box moorings have to be laid, which complicates the junction-box boat work.

The main cables were arranged as follows :—

No. I. for lines 101 to 112.
No. II. for groups A, B, C, D, E, F.
No. III. for groups G, H, J, K, L.
No. IV. for lines 113 to 124.

I. and II. were connected to a test room in Horse Fort.

III. and IV. to a test room in Noman's Fort. All were 7-core cables.

In the Stokes Bay minefield group cables were ready laid and boxes in position; the main cable for lines 201—212 was numbered X.

It was important, in order to ensure a quick day's work, that the test-room parties should get out early to release the dormant buoys, and then the *Pasley* must lay the group moorings before the *Miner* can start work.

Of the junction-box boats, C and D are required first by the *Miner*, and C must move quickly to F to be ready to take the *Miner's* fifth group. The *Miner* should finish her load before the *Pasley*, and get her second load embarked at Blockhouse before the *Pasley* arrives.

The last two groups at Stokes Bay are left to be laid by whichever boat finishes first.

At 7 a.m. the next morning the O.C.S.M. (or Chief, as he was called by his subordinates) arrives at Fort Blockhouse to find a thick white mist covering land and water. The Militia are parading, but there is no news of the Monckton party. But the momentary doubt is soon relieved by the rattle of a chain in the creek, and a hail brings an answer from S.M. Harrison. The test-room and junction-box boat parties are all there, but they are bringing down the pinnaces with the *Farad*, as the miners cannot venture up the creek in the mist. "Any sign of the hired boats ?" S.M. Harrison has not seen them, but a second voice cuts in from a little lower down that the boats are coming over. "Is that you, *Wild Duck?* Are you all right ?" "All right, sir," comes from Tom, the deck hand. "Any chance of a wind, Tom ?" "Yes, it will be all right outside, sir." "Got your party on board ?" "Yes, sir." "Get away then."

The *Sappho* is also despatched, and the Chief moves on to the pier to find S.M. Harrison with the *Farad*, two hired boats just arrived, and the other two close at hand. A few stores are wanted for the test rooms, but the *Farad* is soon despatched, and as she leaves the Fort Monckton parties loom into sight through the mist. The men know their places and are quickly distributed, and after making sure everything is in order, first the *Pasley* and then the *Miner* are despatched, the former with orders to go straight out with her one junction-box boat, the *Miner* to pick up stragglers which fail to catch the wind.

After a word with S.M. Bates, the *Primrose* is off too.

Tom proved a sure prophet, for abreast of Victoria Pier the mist lifts, and the Spithead Forts can be seen as dim shadows in the distance, with the fleet of steam and sailing boats stretched out in a long line—the *Farad* well out, the *Wild Duck* leading the main party. The *Miner* is picking up a couple of boats, and the *Primrose* takes the last and steers straight for Horse Fort. Good work ought to be done to-day if the weather holds; the sea is nearly calm, there is a little breeze, just enough for the sailing boats, and the sun evidently means to be present.

Arrived off Horse Fort, the boats in tow are cast off and the *Primrose* runs alongside the pier. A climb up the gangway, across the gun floor to the inner well, and a steep flight of stairs is reached, leading down to below the water line, where the test room is situated just above the magazines. The first question is: "Have the dormant links fired?" "Yes, all right, sir, and the alignment party say the buoys are floating correctly." This is good news, and is confirmed by a hasty visit to the top of the fort, where the whole fleet is spread out as a panorama. But why is the *Pasley* not at work? A hail on the megaphone explains the difficulty; there has been some change in the arrangement of the alignments, and the officer in charge of the *Pasley* was not quite certain how to proceed. So back to the *Primrose*, and in a few minutes the Chief was on the *Pasley*, and the row of junction-box moorings with their buoys were laid from one side of the channel to the other. These were seized on at once by the junction-box boats hovering round, and the *Miner*, *Pasley*, and *Farad* all got to work. A visit to Noman test room followed, to find all right there, and again to Horse, all mines testing good except D junction box; C and D laid, and part of the lines. Presently the *Miner* whistles and turns her head landward. What is the time? Just 10 o'clock. That's good work; five groups in two hours.

But D box appears to be in trouble, as its boat has not yet moved. On enquiry it is found that the group cable is being re-crowned and a spare box has been put on board.

Presently the *Pasley* has finished her lines and starts cheerily at A and B groups, and as she leaves about 11.15 the *Miner* is seen coming out.

A glance round shows that there is an ominous gap in the line of junction-box boats. The *Wild Duck* has moved, as ordered from C, and taken mines at G group, but cannot move further till her group cable is laid. The boat at D has cleared her fault, but cannot move yet. The boat at E has finished and moved to L as ordered, but

A and B are not ready. There is then no boat ready for H, J, K, the three first groups to be laid by the *Miner*. The *Farad* is busy with a dormant buoy and cannot help.

But F group should be nearly ready by now, and is indeed lowering away her box. So immediately this is clear the boat is pounced on by the *Primrose* and dropped at H just in time to receive the mine cables. Then the boats at A and B are towed in succession to J and K, and the boat at D when clear is ordered to go into Stokes Bay to P group. The pinnace at II. is now clear, and is moved to IV. ready for the next load of the *Pasley*, and the *Farad* lays the dormant buoy at I., shifts the pinnace to III., and goes on with the group cables. A visit to Horse Fort finds all the mines laid so far testing correctly, and the test-room party is ordered to be in readiness to proceed to Stokes Bay.

The *Miner* has brought out a message that the connecting-up parties have left for Stokes Bay, so everything is now going well.

At 12.45 the *Pasley* is out again and starts laying, and at 1.30 the *Miner* has finished her second load and is ordered to take the Horse Fort party and go into Stokes Bay, knock off for a quarter of an hour, and then embark and lay P, Q, R.

At 2.30 the *Pasley* has finished, and the test room at Noman reports all mines good except that one will not buzz. This is ordered to be connected to the group.

There is by now a nice breeze from the south-east, and the junction-box boats are sailing in gaily in turn as they finish their mines. So Q.M.S. Brown and the *Farad* are ordered to lay the remaining dormant buoys, and take both pinnaces and the test-room party at Noman to Blockhouse, while the *Primrose* goes to Stokes Bay. Everything there seems to be going all right; the men are evidently tiring, but are in good spirits, and the *Miner* has taken the last two groups.

But pride goes before a fall, and in laying the last mine but one the cable fouls the *Kingston* valve, and before it can be cleared the *Miner* has been drifted by the tide right across her junction-box boat, dragging the mine over the boat's moorings and mixing all three mines and the group cable into a tangle, while the branch cable is damaged beyond repair.

What is to be done? Shall we be content with our 96 mines and let the last group go? All have been at work for 10 hours and the foul looks a bad one.

But it was a tradition with the Submarine Miners that a day's work once ordered must be finished, and moreover the even 100 mines would be a record for the station. So it was decided to have a try, at any rate. The *Primrose* was sent in for another cable, and officers and men set to to clear the foul.

The *Pasley* had just finished, so Sergt. Stanton and a couple of good men were borrowed to help, while the weaklings were sent to the stern to coil down, and with only half-an-hour's delay the foul was cleared, the moorings re-laid, and the group laid out correctly and in good order. All parties got ashore in time for their well-earned dinner.

The summary of the times of the laying boats read approximately as follows :—

Pasley.—Left pier, 7.10.
Laying 11 buoys, 7.45 to 8.15.
Laying 6 lines, 8.15 to 10.15.
Laying two groups, 10.15 to 11.15.
To Blockhouse, embarking and returning, 11.15 to 12.45.
Laying 6 lines, 12.45 to 2.30.
Going to Stokes Bay and rest, 2.30 to 3.15.
Embarking, 3.15 to 3.45.
Laying 6 lines, 3.45 to 5.15.

Miner.—Left pier, 7.15.
Laying 5 groups, 8.0 to 10.0.
To Blockhouse, embarking and returning, 10.0 to 11.30.
Laying 4 groups, 11.30 to 1.30.
To Stokes Bay and rest, 1.30 to 2.30.
Embarking and laying 3 groups, 2.30 to 4.15.
Embarking and laying 2 groups, with foul, 4.15 to 5.45.

100 mines laid between 7.45 a.m. and 5.45 p.m., or 10 hours' work, with 99 per cent. good. A good day !

CHAPTER XIV.

OTHER WORK DONE BY SUBMARINE MINERS.—ELECTRIC LIGHT. —BOOMS.—WRECKS AND DIVING.—BRENNAN TORPEDO.—ACTIVE SERVICE.—ELECTRIC LIGHT UNITS.—TELEGRAPHS.—ELECTRICAL WORK.—ELECTRICAL COMMUNICATIONS.

IT will be seen from the earlier chapters of this history that while the submarine mining officers received a special training in their special work, they were by no means divorced from the ordinary activities of their corps. Indeed in some respects the influence of the highly technical submarine mining training reacted with great advantage on other branches of military work.

Of these, some grew naturally out of the mining work, such as defence electric lighting, booms and passive obstructions, wrecks and diving, and last, but not least, the Brennan torpedo.

Of other subjects, telegraphs and electrical work generally naturally take the first place, but there is hardly a branch of engineering science in which submarine miners have not done well.

The development of defence electric lighting grew up so intermingled with the mining work that it has been already dealt with in some detail. It may however be desirable here to recapitulate the various stages.

The first experiments with electric-light apparatus were made in 1871 by the Torpedo Committee, but the apparatus remained in the experimental stage till a special committee was appointed at Chatham in 1880.

In 1881, at the Electrical Exhibition at the Crystal Palace, the War Office exhibited several mining and electrical appliances, including a search light.

But electric lighting did not take a proper place in the defences till the experiments at the Isle of Wight in 1889 to 1892 showed its value as an aid against torpedo-boat attack.

The next stage was reached in 1895 with the development of the internal combustion oil-driven engine, and henceforward progress was rapid.

Of booms and passive obstructions little need be said.

They were originally in charge of the Royal Engineers, for the same reason as the mines, as being obstructions to detain ships under gun fire. They have now been taken over by the Navy, and there seems at least the risk that they may be divorced from the gun defence and developed as a complete defence of themselves.

The early experiments of the Royal Engineers were much hampered by two factors, first the want of money, and second the prohibition of spikes, wire rope trails, and other means of damaging attacking ships. A boom is not a cheap form of defence, as it has to be strongly made and moored, but in the early days an allotment of £100 was a large sum to be allowed for an experiment which required £10,000 to be really effective. Thus the early booms were only models, which were attacked by full-size vessels and naturally succumbed. The absence of spikes also is like making a barbed-wire entanglement without any barbs, but little allowance for the difference was made in the early reports of manœuvres.

The destruction of wrecks can hardly, perhaps, be considered as a development of submarine mining, of which it was really the precursor.

The first work of this kind done in the Corps of Royal Engineers was a trial made under Colonel (afterwards Lieut.-General Sir C. W.) Pasley, R.E. (the first Commandant, S.M.E., though not with that title), in 1825. A good serviceable watertight fuze was the chief difficulty. After repeated trials, Colonel Pasley succeeded on the 19th February, 1825, in firing a charge of 11 lbs. of powder, placed in a tin packed in a wooden case and sunk under water. It was fired through a tube (probably lead) 30′ long and 1½″ in diameter, by a hose of ¾″ diameter.

Major-General Whitworth Porter's *History of the Corps* quotes the destruction of the *Arethusa* at Barbadoes in 1831 by Major Reid, R.E., with a party of sappers, under Colour-Sergt. Harris. But as the vessel lay in only 4′ or 5′ at low water, it was practicable to apply a number of small charges close to the keel of the vessel.

Two wrecks were troubling the Thames in 1837–8, the brig *William* and the schooner *Glenmorgan*, the former near Tilbury Fort and the latter nearly opposite East Tilbury Church, towards the extremity of Gravesend Reach. All efforts by the Master-Attendant, Chatham Dockyard, and others to lift these vessels failed. A final attempt to raise the brig *William* failed on 15th December, 1837.

Colonel Pasley then commenced a series of experiments, in which the lead pipe fuzes gave a lot of trouble. After the anticipation of explosions had alarmed the inhabitants of Gravesend, and a few explosions had killed the fishes without much effect on the brig, further work was postponed on the 14th January, 1838, till the spring, when a diving bell was to be used in placing the charges.

In the meantime experiments were continued in the Medway, and the residents in the Dockyard, though terrified by the noises, made a point of stealing every piece of lead piping from the fuzes that might be left overnight in the river.

Experiments were made at the same time with diving dresses, and divers trained to use them. On the 28th April, 1838, Colonel Pasley went down in Mr. Kempt's diving helmet and dress, and Sergt. Young went down after him. On 5th May Corpl. Mitchell went down and drove two eye-bolts in some timber at the bottom of the Gunwharf wall.

Proceedings now recommenced in earnest at Gravesend. Lumps (or lighters) for the diving bell and other divers, etc., were moored close to the doomed vessel, and ladders from them enabled divers to go down. The steamer *Swiftsure* from Gravesend arrived with a red flag to warn passing vessels, and the Admiralty lent some seamen riggers to assist the detachment of Sappers and Miners who were billeted in Tilbury Barracks.

On the 21st May, 1838, Corpl. Mitchell, going down a second time that morning in his diving dress, lost his life in endeavouring to fix a charge under the wreck. Capt. Yule, R.E., the officer in charge, became alarmed on finding that he could get no signal from him, and the life-line was hauled in, and found to be entangled in a portion of the wreck. Colonel Pasley, arriving just after, went down with Capt. Yule in the diving bell with a strong tide running, and after them Sergt. Ross. Corpl. Mitchell's body was at last recovered suspended 9′ above the bottom, his apparatus being caught in the rigging.

On 28th May, 1838, all things being in readiness, and crowds at hand to witness the work, Colonel Pasley's diary says: "Fired at high water. A beautiful explosion. Large column of water and wood thrown up. Part of the step of the mast, deck beams, deck plant, etc. Crowds of spectators. Yule fired the mine. . . . Direct them to sound next morning and to use diving bell. Concourse of boats fishing for timbers."

The result of further examination showed 30′ of water everywhere instead of 18′, and "The brig *William* has ceased to be an obstruction to the Thames, a small part of her bow in a loose state alone remaining."

The size of the charge was 2,500 lbs. of powder. The fuzes used for firing the charges above, and subsequently in blowing up the *Glenmorgan*, were "A linen tape filled with gunpowder, gently wrapped in a spiral form with brass wire, inside a lead pipe (¾″ diameter)."

Submarine mining now made very rapid progress. The *William* was demolished on 28th May, and Colonel Pasley was asked by the Lord Mayor on May 30th to look at the *Glenmorgan*. On 1st June her deck was blown in, and on 5th June a cylinder was exploded.

The same diary records the result :—" Produced a beautiful cone of clear water, succeeded by a waterspout thick with mud, and numerous fragments of fine timber torn to pieces came to the surface . . . 5 fathoms over the schooner's deck before the explosion. Immediately after 7 to 7½ fathoms.

Colonel Pasley was presented by the Lord Mayor with the Freedom of the City in a gold snuff-box, in consideration of clearing the Thames of these dangerous wrecks. Lieut. Hornby, R.E., was also employed in these demolitions.

The cylinder used to demolish the *Glenmorgan* had been prepared for the *William*. It is thus described by General Porter :—" Within a strong wooden buoy was enclosed a leaden cylinder 3′ in diameter and 6′ long, calculated to hold 2,500 lbs. of powder. There were three holes on one side of the cylinder, the centre of which had a short leaden tube about 2′ long fixed to it, closed at the bottom and perfectly watertight, leading from the outside of the wooden buoy to the centre of the cylinder, but having no communication with the charge inside. The other two holes were for introducing the powder, after doing which they were hermetically sealed. A bursting charge of 3 oz. of powder was inserted into the leaden tube at the centre hole, which was then connected with the firing hose. This consisted of a small powder saucisson about $\frac{1}{10}$ of an inch in diameter, fixed in a flexible leaden pipe. The top of the pipe was secured to a small buoy and fired by means of a portfire."

The next considerable development in submarine mining was the use of electricity. A paper by Colonel Pasley was read at a meeting of the Institution of Civil Engineers on the 10th April, 1838, on "Blasting by Galvanism." And experiments made at Chatham, in which Capt. Sandham, R.E., and Sergt.-Major Jones assisted, are described by General Porter.

Daniell's battery was invented in 1836, and first used in submarine mining on the 17th September, 1839, as a firing battery instead of, as latterly, for signalling.

The demolition of the *Royal George* is the largest demolition carried out by the corps, even if any larger have been executed anywhere.

The *Royal George* sank at Spithead in August, 1782, with Admiral Kempenfelt and 600 officers and men. She was a line-of-battle ship of 108 guns, and had been a serious obstruction to the channel for nearly 60 years.

Colonel Pasley asked leave of the Board of Ordnance on the 6th December, 1838, to put himself in communication with the Admiralty on the subject of her removal, with a view to obtaining information and "forming a plan of operations, and computing the cost of its destruction by blowing the woodwork to pieces, and weighing the guns and water-logged oak timber." Work was commenced in 1839.

Colonel Pasley took entire superintendence, going down constantly from Chatham to Portsmouth, and having under him at Portsmouth, Capt. Williams, R.E., and Lieut. Symonds, R.E., and a detachment of Sappers and Miners, under Sergt.-Major Jones, including the most expert divers; also seamen and riggers lent by the Admiralty to assist, and a few civil divers, including Mr. George Hall, of Whitstable. Later in the work none but Sapper divers were employed.

Work was seriously commenced in August, 1839, the first charges being all fired by Bickford's fuze. But a large charge intended to be fired in the same way failed.

The next step was the first use of electricity in submarine mining, and is thus recorded in the *United Service Journal* for February, 1840, in a paper written by Capt. Basil Hall, R.N. :—

"On the 17th September Colonel Pasley made known his intention of firing a charge of 260 lbs. by the voltaic battery, which Lord Durham and his son came to see, and which succeeded perfectly. Lieut. Symonds, R.E., who was about to fire the charge himself, very good-naturedly allowed Master George Malcolm Pasley, the Colonel's youngest son, then 7½ years old, to fire it, at the request of the child, who completed the circuit in the usual manner, after the second bugle sound. This was the first charge fired against the wreck of the *Royal George* by the voltaic battery, and there is every reason to believe that it was the first charge ever fired against any wreck by voltaic electricity, the action of which may be considered one of nature's miracles; for certainly nothing can be more surprising than that the mere tap of one wire against another in a boat or vessel should instantaneously ignite gunpowder and break to pieces the strongest masses of wood and iron at the bottom of the sea, at a great distance from and with perfect safety to the operator."

Following this, an explosion on a great scale took place on the 23rd September, 1839, in the presence of a large and distinguished assemblage. The *Hampshire Telegraph* account, supposed to have also been due to Capt. Basil Hall, is as follows :—

"When the Colonel ordered the bugler who attended upon him to sound the preparative and then the fire, and while the last note of the second bugle sound was still audible, a smart shock like that of an earthquake was felt, and a report like that of a heavy gun at a moderate distance was heard, and in a few seconds afterwards a great column of water, beautifully sparkling in the sun, was thrown up to a height of 30′ or 40′ in the form of a beehive nearly, the appearance of which was heartily welcomed by the cheers of the spectators. After this brilliant jet of water had fallen down, a circular wave, of which the surface was discoloured by mud from the bottom, was observed gradually extending itself to perhaps 100 yards in diameter, nearly in the centre of which the woodwork of the cylinder, broken into small pieces, all lighter than water, came floating to the surface, and gave rise to an amusing scramble of persons in boats rowing to the spot with all haste to seize upon those fragments, which they eagerly carried off as relics."

Work ceased for the winter, and was resumed in 1840. Two charges of 47 lbs. and one of 260 lbs. were fired on the morning of June 22nd, in the position where the main hatchway had been, and at 2.27 p.m. Lieut. Symonds, R.E., using a 10 cells Daniell's firing battery, fired a cylinder containing 25½ barrels or nearly 2,300 lbs. of gunpowder, secured from wet by two coats of canvas, and three of waterproof compositions invented by Sergt.-Major Jones, throwing up first a swell of 3′ or 4′, then a column of water 50′ high, rather rugged, but beautifully bright, and then a black circle, and up came the lower part and heel of the mainmast floating. The diver, George Hall, went down immediately, but found the tide too strong, and a few days after, again going down, he saw a number of "little fishes which rubbed at his hands."

On August 5th, 1840, several charges were fired. "A beautiful explosion more than 60′ high . . . of irregular form, like the foliage of a fine tree, followed by a circle of black mud." The following morning one piece of the kelson, 20′ long, and two other huge pieces were got up.

Among many diving apparatus used, Siebe's diving dress and pump were found superior to others, and it is interesting to note that the same firm, now Siebe & Gorham, have been the principal makers of our diving apparatus up to the present date.

Admiral Sir P. C. H. Durham, G.C.B., who was present at some of these operations, was a midshipman on board the *Royal George* when she sank, but jumped overboard, got hold of a hammock, and afterwards clung to the vessel's mast which was out of the water. Among the articles recovered from the wreck was a spyglass, which was sent to him.

In 1841 the season was rough, and the work appears to have continued steadily and with less public excitement. The amount of timber recovered between 8th May and 28th October of this year measured upwards of 120′ long by 35′ wide and 7′ high, containing 18,600′, or 372 loads.

The demolition was completed in 1843, and was a commercial success, as the proceeds of the sale of the timber and guns and other relics more than paid all the expenses of the work, and the clearing of the channel cost nothing. The Royal Engineers received no remuneration nor rewards. Among other uses of the work, it afforded a great stimulus to salvage work generally. The lumps (lighters), two of which were always at work lifting material to which the divers attached ropes, were commonly resorted to by civilians who had new diving apparatus to test, and the operations excited general interest, and led to the dissemination of intelligence as to the then latest methods and appliances.

Many interesting relics were recovered, but perhaps nothing which was less expected than a lump of butter 18″ long, accompanied by a quantity of tallow candles. There were some, but not many, human remains.

Lieut. Hutchinson, R.E., was also employed in the demolition of the *Royal George*. Colonel Porter records his being afterwards killed at Holyhead, whilst in charge of blasting operations there.

General Porter thus describes the conclusion of the work :—

"On Saturday, November 4th, 1843, the last descent was made by the divers, after which the Master-Attendant of Portsmouth Dockyard reported the ground where the wreck of the *Royal George* had formerly lain was now quite clear, and quite as fit for the use of Her Majesty's ships as any part of the anchorage at Spithead. During the operations . . . upwards of 30 tons of metal (copper, lead, and iron) and 60,000 cubic feet of timber were raised, whilst 54,000 lbs. of powder were expended in the demolition."

In 1844 Colonel Pasley removed the wreck of the *Edgar*, blown up and sunk accidentally by catching fire off the Mother Bank at Spithead in the early part of the previous century, when not a man was saved of those on board. Lieut. Barlow, R.E., with the same excellent military workmen, dockyardmen, naval pensioners, and riggers, were employed in this work, but no civilian divers were employed as at the commencement of our operations at Spithead.

These early demolitions are remarkable for their success. Our difficulties of even 20 years ago in ensuring the success of any explosion except under the rigid conditions governing service mines, and five years earlier the uncertainty of even service mines carefully prepared, warrant an interest in the details of charges and fuzes in these early times. In a letter from Sir C. W. Pasley to Mr. Manby, dated 9th February, 1855, it is stated :—

"Your correspondent must not attempt simultaneous explosions, or to make use of one conducting wire, trusting to the water to complete the circuit. These expedients were tried repeatedly in 1843 by Capt. Hutchinson, who was very zealous about them ; but we lost a great deal of powder by the first, as we never succeeded in firing more than two charges simultaneously out of a great number, and the cases containing the second charge were generally burst, and the powder spoiled, by the explosion of the first that happened to prove successful.

"The second of these expedients gave more trouble, and required a battery of double the power to produce the same effect. We therefore in all cases used a voltaic battery and two conducting wires to every charge in our operations against the *Edgar* in 1844."

In a paper dated 10th April, 1838, by the same author, it is recorded that Bickford's fuzes were the first adopted by the R.E. Establishment, Chatham, in the time of 1834. "Great advantage is derived from the use of Bickford's fuze applied to tin powder cases; also from the system of tamping by means of small stones. But the ordinary Bickford's fuze, though superior to every other in shallow water, cannot altogether be depended upon in depths of from 5 to 10 fathoms. The general practice has been to ignite the powder contained in a tin canister by dropping a piece of red-hot iron down a tin tube reaching to the surface."

The tin tubes being found liable to failure, flexible leaden tubes and a piece of portfire instead of red-hot iron for vertical explosions was used. The paper continues :—

"Several other methods of firing, as small rockets, a quick match, and small linen hoses, were tried, but without success. A small fine powder hose, about $\frac{1}{8}''$ in diameter, secured so as to burn gradually instead of rushing forward to explosion, was found to succeed very well, but is neither so simple nor so cheap as Bickford's fuzes. These fuzes consist of so minute a thread of fine powder that they burn rather than explode, and are in no danger of bursting the case, which is made of twisted hemp coated with pitch, and so performs the double duty both of the hose and the metal tube. . . . When a large quantity of powder is to be fired, the time which the fuze is burning, namely, about half an hour in 8 fathoms of water, keeps the experimenter in a great state of uncertainty as to when the fuze has ceased to burn. . . . In these cases a small hose and leaden pipe are preferable."

And in a manuscript dated 24th April, 1838, the same authority gives the details of the early arrangements for firing electrically, suggested by him in a paper already quoted, the first employed seriously on the wreck of the *Royal George*. He says :—

" . . . but great difficulty has arisen in igniting the powder. A fuze of cotton steeped in spirits of wine and gunpowder and enclosed in a caoutchouc tube was first used . . . being uncertain and expensive. The idea occurred of trying galvanism. It is well known that when two ends of copper wire leading from the poles of the battery are connected by a piece of platinum or iron wire, the latter becomes red hot. To apply this method, the top of the tin canister which contains the charge is fitted with two copper wires about 6″ long, passing through a piece of cork and connected at their lower ends by a piece of platinum or iron wire. The canister being charged, the platinum or iron wire is pushed down into the middle of the charge and the top of the canister cemented on with putty. The wires are well coated with a non-conducting medium, as a mixture of resin, wax, and tallow, or caoutchouc, excepting at their lower ends, where they are connected with the two long copper wires which proceed to the battery. These connecting wires, covered with cotton thread, are coated with the caoutchouc varnish and then tied together, so as to form one rope. The diver, having connected the wires of this rope with the wires of the canister and uncoiled a sufficient length of rope, descends and deposits the canister in the rock or hole prepared for the blast, and returns to the surface. The other ends of the wires are then dipped in the mercury cups of the galvanic battery, and the platinum wire becoming instantly red hot, the charge is exploded. There is not more than about 6″ of the wire lost at each discharge. The security, certainty, and convenience of this plan are evident. In quarries any number of charges could be fired at the same instant or in rapid succession, and this method possesses incalculable advantages over any other for the military engineer, since any number of mines could be exploded at the precise moment that is desired."

The final words of this extract, though negatived in the letter of 1855, previously quoted, have proved true after a great deal of development and many modifications of the fuzes and detonators, as well as firing batteries of modern defence submarine mining.

From the time of Colonel Pasley, diving and firing mines electrically seem to have been included in the curriculum of the Chatham School of Engineering. Diving gear and electrical firing apparatus were sent to the Crimea in 1854.

In 1870 and 1871 an iron ship of 2,768 tons, the *Golden Fleece*, which had been sunk off Cardiff in 1869, was successfully broken up by a small party of R.E., under (first) Lieut. H. Jekyll and (later) Lieut. R. F. Moore.

This was one of the first iron ships to be destroyed in this way, and the cost of the operation, £2,000, was considered very moderate, but it took Lieut. Moore, in 1871, seven months of hard work, during which he used 2,500 lbs. of guncotton and 12,000 lbs. of gunpowder. Corpl. Attwood (afterwards an officer of the Coast Battalion) was the N.C.O. in charge of the detachment.

In the early eighties there was a great demand for divers for various civil works in progress, including the Tay and Forth Bridges; the attractions of higher pay proved too much for the R.E. divers. It was therefore found necessary to withhold the certificate which had formerly been given to these men on completion of their course until they completed their service with the colours.

The diving work was always very carefully carried out, and a very excellent standard was set by the staff at Chatham. Although improvements in mining made it unnecessary to employ divers in connection with the mines, they proved very useful for clearing foul screws or under-water valves, and for work on wharves and piers. Several good pieces of work were done in connection with the Brennan torpedo, notably the recovery of the first Brennan, which had sunk in the deep hole off Garrison Point, by Sergt. F. White.

The development of civil salvage companies gradually made it unnecessary to employ military divers for wrecks in England. But in India it was quite an ordinary event for the Submarine Mining Section to tackle a wreck or two a year, or to be employed outside the practice period in such work as sinking caissons for large railway bridges, removing sunken rocks, or laying foundations under water.

Among these may be mentioned :—

In 1884, at Calcutta, the wrecks of the *Aurora* and *Ellen Stuart*, a large wooden platform on girders, and the tug boat *Reliance* were cut in pieces and were removed.

At Rangoon a sunken dock was destroyed.

In 1885–86, at Rangoon, a small steamer, the *Lapwing*, was blown up.

In 1886, Calcutta cleared away two cargo boats, and Rangoon began work on a river steamer—the *Shouylayoung*.

In 1887, Rangoon had two cargo boats to deal with.

In 1891, Rangoon cleared a cargo boat of 70 tons, and at Calcutta a three-masted ship of 800 tons was successfully broken up.

It is also noted that this year Lieut. A. J. Pilcher claims to have made rain by firing some charges in the famine district in Burma, but his efforts were rather discounted by the appearance of a cyclone the next day.

In 1892 an iron ship was destroyed at Rangoon, and some difficult diving work carried out in repairing broken screw piles under water.

In 1894 a sunken lightship was destroyed at Rangoon.

In 1895, Calcutta carried out a neat operation in the destruction of an iron flat $160' \times 24' \times 7'$ loaded with rice, which had sunk in about 2 fathoms at low water. Work commenced at 7 a.m. on 13th June, and at low water on 15th June there were 8 feet clear water over the wreck at low tide. 520 lbs. of guncotton were used.

In 1897, Calcutta had four small wrecks to tackle, and at Rangoon there was a little variation in the form of a sunken pagoda 100′ square, which was successfully shattered, in addition to a stern wheeler and some rocks.

In 1898, Calcutta dealt with a large iron vessel off Hughli Point and smaller jobs, while Rangoon cleared the wreck of the river boat *Pagan* in the Chindwin River, the boat being cut up by explosives and the engines recovered. A sunken cargo boat in Rangoon Harbour was also dealt with, and as the report says, "presented no difficulties."

In 1899, Karachi successfully removed two rocks weighing 2,200 tons, which obstructed the defence electric lights, Calcutta cut off the masts and funnel of a Government Survey vessel sunk in the Hooghly, and Rangoon, in addition to small jobs, tried to carry out salvage operations on an oil-tank steamer, *Kokine*, but unsuccessfully, and began the destruction of the s.s. *Burma*, which seems to have formed a sort of "stock job" for three or four seasons.

In 1900, Karachi cleared another rock, Calcutta had a couple of

Diving Party.

minor wrecks, and Rangoon, in addition to the *Kokine* and the *Burma*, had another cargo boat to deal with.

In 1901, Rangoon had a change of work in the construction of a raft on the lakes, on the occasion of a visit from the Viceroy to Rangoon.

In 1902, Calcutta had to handle the wrecks of s.s. *Karagola* and s.s. *Deepdale*, and Rangoon, in addition to breaking up two cargo boats and a pontoon, was employed on recovering three launches and one cargo boat, all sunk in a heavy cyclone that year.

One of the most important services rendered by the Submarine Miners was in connection with the trials and purchase of the Brennan torpedo.

This wonderful weapon was invented by Mr. Louis Brennan, an Irishman domiciled in Australia, who patented the invention in 1877.

It was first offered to the Admiralty, who refused to bear the expense of trials. They however detailed certain naval officers to inspect the model torpedo at Woolwich, in company with Lieut.-Colonel Lyons, R.A., Inspector, Royal Laboratory; these officers reported that the torpedo was not suitable for use on board ship, but that further trials were desirable from forts.

The R.E. Committee was then asked by the War Office on 8th August, 1881, to report on the torpedo.

The Commandant, S.M.E., and President, R.E. Committee, was at the time Sir A. Clarke, who was immensely impressed with the importance of the new weapon, and on 30th May, 1882, the R.E. Committee reported favourably on the full-size model they had seen, and recommended that an improved pattern of torpedo be constructed at the expense of the Government.

Mr. Brennan was accompanied to England by Mr. J. Temperley, and financial backing to the scheme was given by various gentlemen in Australia, who had formed themselves into a company to support the invention. The terms asked by this company were £100,000 down for the exclusive rights in the invention, or £30,000 for the use of the invention without exclusive rights.

The whole question was then referred to an influential committee, composed of Lord Morley, Under Secretary of State, Sir J. Adye, Surveyor-General of the Ordnance, Sir F. A. Campbell, Director of Artillery and Stores, and Sir A. Clarke, Inspector-General of Fortifications.

This Committee reported on 1st September, 1882, that they had no doubt of the value of this torpedo invention, but were less confident that the secret could be kept. They endorsed the recommendation of the R.E. Committee that further experiments should be carried out at Government expense.

In accordance with this recommendation, an agreement dated

13th February, 1883, was made with the Brennan Torpedo Company to pay down a sum of £5,000 towards the expenses of Mr. Brennan and Mr. Temperley in coming to England and conducting the trials up to date, and engaging Mr. Brennan at a fixed salary for a term of three years, during which he was to give his whole time to improving and perfecting his invention, and was to explain the secret of the invention to certain named officers, but not to divulge it otherwise. The Government were to meet all expenses of the trials.

Provision was further made that at any time Mr. Brennan might give notice that his torpedo was complete, and that the agreement would determine two months after the date of such notice, during which time the Government had the option of purchase on terms to be arranged. If they did not exercise the option, the torpedo was to become the property of Mr. Brennan, and the officers who knew the secret were to be morally bound not to divulge it.

In pursuance with this, an experimental installation was set up at Sheerness, where an engine designed by Major English, R.E., was provided at a cost of £2,144, and a workshop at Chatham with a few men were placed at the disposal of Mr. Brennan.

The supervision of the experiment was delegated by the R.E. Committee to a sub-committee composed of Major M. T. Sale, Capt. R. M. Ruck, and Capt. A. T. Preston, with Commander Chisholm-Batten, R.N., and Lieut. L. B. Friend as Secretary.

This Committee watched the whole of the trials, and in 1885 instituted a very searching series of tests at fixed and moving targets which were successfully complied with by Mr. Brennan.

The details of the mechanism and the secret parts were also shown and explained to Major Sale, Capt. Ruck, and Capt. Preston, to ensure that there was nothing in the mechanism which was beyond the capabilities of the Royal Engineer officers and men. These officers reported that there was no new principle involved in the mechanism, but that the application was very ingenious, and unless anybody was acquainted with all the details it would probably take a very long time before the torpedo could be re-designed by any outside person.

They also reported that they saw no difficulty in enclosing the more important parts in boxes which could be closed up at home and issued closed to stations, and returned intact if repair were required.

But it was still considered that the torpedo was capable of improvement, and the agreement with Mr. Brennan was extended for a year, till February, 1887.

In June, 1886, another Committee was assembled consisting of Hon. H. S. Northcote, Surveyor-General of the Ordnance, Lieut.-General Sir L. Nicholson, Inspector-General of Fortifications, Brigadier-General A. J. Alderson, Director of Artillery and Stores, and Rear-Admiral Hopkins, Director of Naval Ordnance.

This Committee discussed very carefully the reports of the trials, and especially the possibility of maintaining the exclusive rights, and finally recommended the purchase.

Meanwhile, in October, Mr. Brennan had given the notice provided in his agreement, and an application was then made to the Admiralty to join in the purchase of the torpedo.

In reply, the Admiralty wrote, on 11th November, 1886, that they do not consider the torpedo suitable for naval service and must decline to expend money from naval votes, but they were willing to join in a statement to the Treasury that it is in their opinion desirable to purchase the invention as a valuable weapon for the protection of harbours, coaling stations, etc. They however doubted the possibility of maintaining the secret. It was then found necessary to extend the two months during which the option of purchase rested with the Government, and on 1st December, 1886, Mr. W. H. Smith, the Secretary of State for War, who had taken a great personal interest in the invention, wrote to the Treasury asking them to name an official to assist the above Committee in discussing terms with Mr. Brennan.

By the following January, 1887, terms had been settled, and a formal agreement was despatched for the concurrence of the Brennan Torpedo Co.

The terms were a payment of £110,000, of which £30,000 was paid down at once, and the remainder in five yearly instalments of £16,000, while, to ensure the maintenance of the secret and to provide for manufacture, Mr. Brennan and Mr. Temperley and a foreman who was acquainted with some of the details of the secret were retained at fixed salaries for a term of five years for exclusive work under Government.

Arrangements were at once made to commence manufacture, the ports at which it was decided to instal torpedoes were selected, and steps taken to begin the training of the necessary *personnel.*

This naturally took some time, and it may be here explained that the arrangements to maintain the secret were successfully introduced, and up to the present date, 21 years after the purchase of the invention, no torpedo of a similar type has been developed by any foreign Government.

As a weapon, within its limit of range, it proved remarkably efficient, and as its weight and pace were sufficient to carry it through the ordinary torpedo netting, and it was quite invulnerable during its run, no satisfactory means of meeting its attack could be designed.

As regards its position in the defence, it is comparable with an observation minefield, with the added advantages of requiring no restriction of the navigable channel and no interference with the use of the water for any purpose until the torpedo is launched.

Further, as soon as one torpedo was fired a second could be launched, so that the defence was intact until the whole battery of torpedoes had been discharged.

As this weapon is still retained in our defences, it cannot be described, and it is sufficient to state that at the time of its introduction it was much superior to the Whitehead in all the essential factors of speed, size, range, and amount of charge.

To provide for the proper training of *personnel* Lieut. E. C. Seaman was appointed Assistant Instructor at the Chatham School on 1st April, 1890.

When first installed the necessity for a high standard of training in the operators and frequent practice was not perhaps sufficiently understood.

But a system of automatic records was installed both in the torpedo itself and in the engine room, which were sent in each year to Chatham from all Brennan stations, and from these the Assistant Instructor was able to check not only the general work, but also the detailed running of each torpedo and engine.

About 1894, when the first supply of torpedoes was completed, experiments were begun to improve the torpedo by using a thicker wire to transmit the power and higher strains, and an experimental installation was placed on board a steam vessel, the *Sir Howard Elphinstone*.

Not only did this prove a satisfactory base for experiments, but also it proved that the torpedo could be successfully operated from a ship, whether at rest or underweigh; in fact, many of the launching difficulties were avoided by the floating installation. This latter also proved a useful reserve in case one of the permanent home installations had to be laid up. The experiments with the thicker wire made it necessary to partially re-design nearly every part of the torpedo mechanism, but this was successfully accomplished and the changes were carried into effect.

In 1896 Mr. Brennan handed over the charge of the factory to Capt. MacAdam, but remained in the factory as Consulting Engineer, and continued to give a great deal of his time to experiments and design.

This short summary of a wonderful weapon would not be complete without a special reference to the genius of Mr. Brennan as an inventor. When the resources of modern engineering did not provide a method or material to meet some difficulty which had arisen, Mr. Brennan was always ready with a novel suggestion, many of which have proved fruitful in other capacities.

Of active service in connection with mines, the submarine mining officer never got beyond the stage of the war scare, a disability which he shares with practically the whole of the British Navy; but when employed on active service in other branches of engineering they have uniformly done well.

On the first formation of the service a definite promise was made that officers undertaking submarine mining duties would be specially considered for employment on service with the army telegraphs. Unfortunately the rapid development of submarine mining in the eighties prevented the submarine mining officers from being spared for other duties, and up to the outbreak of the South African War they had distinctly less than their share of opportunities.

In South Africa, thanks to Major-General Sir W. Salmond, the Submarine Miners had their share.

Of officers who have been employed in various campaigns, mention may be made of the following :—

Lieut. H. Jekyll was in charge of telegraph work in Ashantee, 1873-74.

Capt. Anstey, Capt. Heneage, Lieuts. C. Penrose, M. A. Cameron, and T. Brotherton were in Zululand, 1879.

Lieut. T. Brotherton was with Sir P. Colley at Laing's Nek in 1881.

In the Afghan War of 1878-81 the Submarine Miners were represented by Capt. E. P. Leach, whose experience as a Submarine Miner was however limited to a full course on the *Hood* in 1878, and Lieut. A. H. Randolph, who joined the S.M. Service in India at the end of the campaign. As it was before the days of submarine mining work in India, it is not surprising to find no other names.

In Egypt, in 1882, the following Submarine Miners were employed :--Major Chermside, Capt. C. M. Watson, and Lieut. V. Caillard for special service, Capt. Whitmore for telegraphs, and Lieuts. F. Bennett, Vidal, and Dopping-Hepenstal for railway work, with Capt. G. Barker as Adjutant, 1st Division. Capts. Watson and Barker received Brevet Majorities for this campaign.

Majors Chermside and Watson remained in Egypt and were attached to the Egyptian Army.

In the expedition of 1884 to the relief of Khartoum Capt. Von Donop and Lieut. Vidal were with the 8th (Railway) Company, Capt. Bennet and Lieuts. Tower and A. M. Stuart with the telegraphs, and Lieut. Dumbleton on special service, while Major Chermside was appointed Governor of Suakim. With General Graham's force in 1885, Lieut. Bowles with the telegraphs was the only submarine mining officer. In the list of honours for this campaign, Chermside got a Brevet Lieut.-Colonelcy and Bennet was made a Brevet Major. It is unnecessary to recapitulate here the work of Chermside and Watson in Egypt in the years subsequent to 1886.

In the Egyptian Campaign of 1897 occurs the name of Major L. B. Friend.

In the Boxer Expedition of 1900 in North China Lieut.-Colonel C. Penrose, Major F. V. Jeffreys, and Capt. A. Rolland were old submarine mining officers, while Lieut. A. C. J. Stevens was at Wei-hai-Wei.

In the South African War of 1899—1902 nearly 40 past and present submarine mining officers were employed, of whom the best known were Lieut.-General Sir H. Chermside, Commanding Division, Lieut.-Colonel C. K. Wood, C.R.E., Natal (Brevet Colonel), Lieut.-Colonel H. E. Rawson, C.R.E., Line of Comns., Natal (Brevet Colonel and C.B.), Major W. F. Hawkins, in charge Telegraphs, Natal (C.M.G.), Major S. R. Rice, C.R.E., Ladysmith (Brevet Lieut.-Colonel).

In addition to these, the following were mentioned in despatches :— R. Anderson, D. Brady, P. R. Burn-Murdoch, Clifford Coffin, J. H. Cowan, F. E. Harward, G. F. Leverson, F. L. Lloyd, W. C. Macfie, R. L. McClintock (Brevet Major, D.S.O.), S. L. Owen, D. H. Ridout, W. M. Thomson (Brevet Major), N. G. Von Hugel, R. S. Walker.

There were three casualties among submarine mining officers, Capt. E. G. Young and Lieut. R. E. Meyricke succumbing to illness, while Lieut. R. Anderson died of wounds.

In the Indian campaigns the submarine mining officers had their full share of war service, and over 20 officers have participated in various campaigns, of whom mention may be made of Lieut.-Colonel W. J. Dundee, C.I.E., and Bt. Major G. A. J. Leslie.

An interesting development of the South African War was the formation of field search-light units. Two of these were formed as regular units, mainly from the Submarine Miners, under Capts. Dumaresq and D. H. Ridout. A large number of the Electrical Engineer Volunteers also went out for the same duty under Major Crompton. Capt. F. L. Lloyd, R.E., accompanied this unit. Although not required for the anticipated Siege of Pretoria, these detachments did excellent work in other ways, and one of the R.E. units was later turned into a field troop. In the later stages of the war there was a great increase of electric-light plant for use on armoured trains, with mobile columns or with the blockhouse lines. At one time over 70 projectors were in use in one way or another.

Of N.C.O.'s and men who did good work mention may be made of Sergt.-Majors H. E. Burton and G. A. Brown, who both afterwards received commissions in the Coast Battalion, and Sergt. J. J. H. Brown, who was specially mentioned in despatches and received the medal for distinguished conduct.

In addition to these special units a large number of N.C.O.'s and men were employed with other R.E. units, especially for telegraph, railway, and steam transport.

The connection between the Submarine Miners and the Field Telegraph Service was always a very close one. Started as organized units about the same time, they for 15 years shared the same school of instruction, and there has always been a considerable exchange of officers between the two branches, especially in the dismounted telegraph division employed under the Post Office. Several of the heads of this division have been submarine mining officers, as Addison, Von Donop, Wrottesley, Hawkins, Bowles, and Davy. Wrottesley was selected as Director of Telegraphs for the South African Force in 1899, and was on the way to take up the work when he was unfortunately washed off the deck of the transport near Madeira.

Although not specially connected with their work, several submarine mining officers have done good service with the Survey Departments both at home and in India, among whom may be mentioned, in addition to General Stotherd and S. Anderson, G. E. Smith, now Director of Survey, East Africa, and G. F. Leverson, Dumbleton, Guggisberg, and Woodroffe, who have been employed on various boundary commissions in Africa, and G. A. J. Leslie, with the Indian Survey.

The work in the Inspection Branch at Woolwich has been already dealt with in some detail.

An allied branch was the R.E. Committee, which from 1870 onwards was very closely connected with the development of submarine mining, and of the early secretaries who helped materially, mention may be made of Capt. M. T. Sale, 1876 to 1880, who a few years later was a member of the Committee when the recommendation was made to adopt the Brennan torpedo.

From 1881 to 1902 the following submarine mining officers were Secretaries of the Committee :—

Capt. G. Barker	1881.
Capt. G. W. Addison	1882.
Lieut. L. B. Friend	1884.
Capt. H. E. Rawson	1889.
Capt. E. Druitt	1894.
Major G. A. Carr	1899.

At first all business was transacted by the full committee, but as the technical work of the Engineers increased both in quantity and quality, it was found necessary to delegate the work to sub-committees, that dealing with mines and lights being usually composed of the Inspector and Assistant Inspector at the War Office, the Instructor at the Submarine Mining School, Chatham, the Instructor in Electricity (for lights only), and the Inspector, R.E. Stores. This sub-committee had a good many subsidiary questions referred to them, in addition to such matters as the pattern of a mine-case or the specification of a generator, and on one occasion a session of five hours was taken up in the selection of new screw-cutting gear for the whole army.

Reference has already been made of the special sub-committee composed of Major M. T. Sale, Major R. M. Ruck, and Major A. T.

Preston, which with Friend as Secretary carried out some very exhaustive trials of the Brennan torpedo before that weapon was adopted into the service.

Of electrical work generally other than that required for the firing of charges, practically all the military work, with the partial exception of army telegraphy, owes its growth to the submarine mining officers and men.

In the early days all branches of electrical work were concentrated in the Electrical School at the S.M.E., but even after the separation of the Submarine Mining School, all the officers on the staff of the Electrical School, S.M.E., with the important exceptions of Major Hippisley and Major Bagnold, were drawn from the Submarine Miners.

At the War Office, as soon as the electrical work required separate representation, it devolved on the branch of the Inspector of Submarine Defences. Among other subjects dealt with were regulations for lightning conductors on military buildings, while there has been a large development of electric lighting in barracks, of which the special installation at Aldershot is the most conspicuous example. The electric lighting of the camp for the Delhi Durbar of 1902 was entrusted to Major A. M. Stuart and the sappers of the Indian Submarine Mining Company. In addition to these, modern developments have required a considerable increase of electrical communications, both in fortresses and for telephonic work. These have also been dealt with mainly by the Submarine Miners. In short, the latter were essentially the electrical branch of the Royal Engineers, and the head of that branch at headquarters was and remains the Electrical Adviser of the War Office.

Of submarine mining officers who hold, or have held, senior military appointments may be mentioned :—

On the Retired List.

Lieut.-General Sir H. Chermside, G.C.M.G., C.B.
Colonel F. R. de Wolski.
Colonel E. D. Malcolm, C.B.
Colonel A. Featherstonhaugh.
Colonel G. W. Stockley.
Colonel Sir Charles Watson, K.C.M.G., C.B.

On the Active List.

Major-General G. Barker, C.B., lately Inspector of Royal Engineers.

Major-General R. M. Ruck, in charge of Administration, Eastern Command, and lately Director of Fortifications and Works, War Office.

Brigadier-General C. V. Wingfield-Stratford, Chief Engineer in Ireland.

Brigadier-General L. B. Friend, C.B., Commanding Scottish Coast Defences.

Brigadier-General F. Rainsford-Hannay, Director of Fortifications and Works, War Office.

Colonel H. E. Rawson, C.B., lately Chief Engineer, Northern Command.

Colonel C. Penrose, Chief Engineer, Southern Coast Defences.

Colonel J. H. Cowan, A.D.F.W., War Office.

Colonel G. F. Leverson, Chief Engineer, Malta.

In addition to the above it is interesting to note, as having especially distinguished themselves in other branches of activity, the names of:—

Sir W. Crossman, K.C.M.G., late M.P. for Portsmouth.

Sir Vincent Caillard.

Major M. A. Cameron, Crown Agent for the Colonies.

Major P. Cardew.

Mr. O. Chadwick.

Sir Herbert Jekyll, Assistant Secretary, Board of Trade (Railway Department).

Sir Montagu Ommanney, late Permanent Under Secretary for the Colonies.

Major-General E. Harding Steward, C.M.G.

While the work in the Intelligence Branch of Lieut.-Colonel J. E. Edmonds and that of Brevet Major Sir A. Bannerman, as Military Attaché at Port Arthur, are worthy of record, and also the work of Major W. P. Brett as Instructor and Professor at the R.M. Academy between 1894 and 1903.

This history would hardly be complete without some mention of the recreations and amusements of both officers and men.

In the early days at Chatham, when the service was only growing, many of the keenest officers were glad to volunteer for a new and interesting branch, and the result was a general proficiency at games, quite out of proportion to the small numbers employed.

At cricket Renny-Tailyour was not only the champion of the R.E., but one of the best amateur cricketers in the country, while of the R.E. team which made the record score of 725 in 1875 four were Submarine Miners. Among other enthusiasts may be mentioned C. Wingfield-Stratford, H. E. Rawson, P. Von Donop, C. K. Wood, F. W. Heneage, L. B. Friend, H. N. Dumbleton, E. Druitt, and others.

At football R. M. Ruck was for some years the captain of the R.E. team, and G. Barker, Wingfield-Stratford, Von Donop, Rawson, Renny-Tailyour, Middlemass, C. K. Wood, O. E. Ruck, J. Cowan, R. E. Hedley, Vidal, and Druitt were all regular players.

At billiards Dumbleton was for some years the R.E. champion in the annual match against the R.A., and at racquets Penrose, Friend, and Tower all represented the corps.

At yachting, which from its nature might have been expected to be a speciality of the Submarine Miners, there has been no such monopoly, for against the names of M. A. Cameron, P. Cardew, A. M. Stuart, W. S. Vidal, H. V. Kent, F. L. Lloyd, and F. Baylay may be put Sir G. Leach, Sir C. Warren, Sir J. R. L. Macdonald, the two Bogles, and many others.

Of the N.C.O.'s and men, two forms of recreation may be mentioned, rifle shooting and rowing.

When the R.E. Inter-Company match was started in 1880, it was strongly supported by the Submarine Miners, and for the first three years, both the 1st and 2nd places were taken by submarine mining companies.

In 1880–81 the 23rd Company was 1st.
„ 28th Company was 2nd.
In 1881–82 the 4th Company was 1st.
„ 23rd Company was 2nd.
„ 28th Company was 5th.
In 1882–83 the 23rd Company was 1st.
„ 4th Company was 2nd.
„ 33rd Company was 6th.

A good record considering there were only four submarine mining companies all told in those days.

Of later records, mention may be made of the excellent shooting of the 28th and 34th Companies at Gravesend and Malta, both in R.E. and Army Competitions.

But perhaps the most distinctive recreation was the cutter racing in heavy 12-oared cutters of naval type.

At a keen station the formation of the cutter's crew was one of the events of the summer, an honour to which the raw recruit could aspire, but jealously guarded by the older hands.

The charge of the crew was generally taken by one of the senior warrant or N.C.O.'s; the sergeant-major, where there was one, if not the company-sergeant-major, was expected to officiate. The training was long and arduous, and was carried on outside working hours. It usually lasted about three months, during which time the lucky (or unlucky) aspirant to rowing honours had to be up with the lark for a couple of hours' hard rowing before breakfast and a similar amount after afternoon work. Strict moderation in drinking and smoking was enforced, and the rowing with a good crew was a sight worth watching, with the crew working as one man, getting well forward, and swinging back till their heads nearly touched the man behind, while at each mighty stroke the boat seemed to jump forward, leaving a great wake of steaming foam.

The ordinary cutter was not well adapted as a racing boat, and it was usual to raise the height of the seats, to fit stretchers and to weight the inner end of the oars. In addition bottom boards and every ounce of spare weight were removed, and an especially energetic cox would add a small leaden cutwater. Before each race the boat was carefully hauled up and dried and the bottom coated with blacklead. It was often urged that these additions departed from the definition of "service" cutters, but as all competitors did the same, this did not much matter.

A more difficult thing was to get a boat with good lines; though to the uninitiated they all looked alike, there was in reality considerable difference in the pace of different boats, and a station which happened to get a good boat used to take good care of it. The storekeeper also usually managed to keep a special set of oars for the racing cutter.

The races used to take place at the local regattas, or sometimes private matches were arranged, often for considerable stakes. The principal opponents were the Royal Navy and the Dockyard hands, while occasionally other crews would be entered. As a rule the Navy did not form very stout adversaries, as their stroke was too short to contend with the long sweeping stroke of the Sappers, but the Dockyard hands had some excellent crews, and with them it was a case of "honours easy."

In 1899 Sir Charles Warren presented a shield for a championship race on the River Medway, which was won for the first two years by the Naval School of Gunnery, Sheerness.

But in 1905, the last year of the service, a good crew of Submarine Miners, under Sergt.-Major Darby, succeeded in gaining the championship.

CHAPTER XV.

THE REORGANIZATION OF THE SUBMARINE MINING SERVICE.

IMMEDIATELY on the receipt of the decision of the Committee of Imperial Defence, that mines were to be handed over to the Navy, a Committee was assembled at the War Office to consider the best method of giving effect to this decision.

Brigadier-General R. M. Ruck was President of this Committee, and the members were Colonel R. C. Maxwell, A.A.G., R.E., Capt. Purefoy, R.N., Major Handley, R.A., Major G. M. Harper, R.E., and Mr. Patterson representing the finance branch. Major Baker Brown was Secretary.

Capt. Purefoy and Major Dumbleton were at once nominated as delegates for this Committee, to visit stations and arrange for the transfer of stores, buildings, and vessels.

The Committee reported on home stations in February, 1905, and on all stations in October, 1905, and the result of their recommendations, which were discussed and amended by the Army Council, will be understood from the changes summarized below.

Attached to their report were tables showing the value of the submarine mining stores, etc., as estimated by the Committee, which give some idea of the capital invested in this form of defence.

The actual mine stores were estimated at £314,870.

The submarine mining buildings, piers, etc., were estimated at £244,000, excluding the value of land, and excluding test rooms and observing stations.

The submarine mining vessels and boats, excluding the launches retained for other R.E. work, were estimated at £249,310.

The numbers of the *personnel* employed, excluding India, was stated at :—

Regulars	Officers	95
	Supernumerary Staff	193
	Others	1,908
Special Reserve		400
Militia	Officers	58
	Permanent Staff	59
	Others	751
Volunteers	Officers	122
	Others	1,805
Local Forces		230

Of the above it was estimated that 87 officers, 141 Supernumerary Staff, and 1,824 men of the Regulars would be required to man the electric-light defences, so that the saving of Regulars would be 8 officers, 52 Supernumerary Staff, 143 others, including 59 of the Militia Staff.* It was recommended that the Militia officers should be retained, but the Militia men and the Special Reserve should be disbanded. The Volunteer Corps were to be retained with reduced establishments.

It was pointed out that some vessels and boats were required for use with the Brennan torpedo and for transport at the electric-light schools. Also that at every station some buildings must be retained for use as offices, stores, and workshops in connection with the electric-light defences.

The nett financial annual saving on the whole service after the withdrawal of garrisons at Halifax, Esquimault, St. Lucia, and Trincomalee, but including provision for the electric lighting at Gibraltar, came to £124,470.

The value of the stores, buildings, and vessels to be transferred to the Navy came to £908,000.

In the original decision of the C.I.D. no mention was made of barracks, but as soon as the actual transfers began the Admiralty claimed the barracks in which the Submarine Miners were quartered. It was pointed out that these were required for the men retained for electric-light work, and that only a few men at each station would be actually reduced. The question was therefore referred again to the C.I.D., who decided that the Admiralty could take the barracks, but must re-provide any accommodation actually acquired by the War Office. Finally Br.-General Lawson was made President of a mixed Committee, which after some discussion recommended that the accommodation in Fort Blockhouse should be transferred to the Navy in lieu of all claims to barracks at other ports.

Two other Committees were necessary before the changes consequent on the withdrawal of mines could be completed.

The first was an important Joint Committee, under the Presidency of General J. F. Owen. This was assembled to report on the changes of armament, etc., consequent on the withdrawal of mines, but it was very soon realized that the change of opinion on the part of the Admiralty would affect the whole defensive arrangements, so that the work of this Committee was practically a re-armament of the whole defences of the Empire.

* A later detailed calculation showed that only about 400 of the Regular R.E. could be considered as employed solely on submarine mining in charge of test rooms and observing stations or as crews of boats. The difference between this figure and the saving given by the Committee was due to the fact that some of the electric lights were not yet provided with *personnel*.

Their detailed reports, while involving considerable reductions in guns and incidentally in the strength of the Garrison Artillery, also recommended many new batteries and lights. The cost of these, which were mainly necessitated by the withdrawal of mines, totalled £300,000, which amount is now being expended.

The last Committee was under the Presidency of Lieut.-General Mackinnon, and assembled to consider detailed proposals for the future organization of the Militia and Volunteers. A great deal of evidence was taken from officers interested, but the general result was to confirm the recommendations of General Ruck's Committee.

As soon as the reports of these Committees were digested in the War Office, steps were taken to give practical effect to their proposals. It was obvious that the withdrawal of mine defences would leave the R.E. fortress organization in a very shattered state, and that to effect a complete reorganization it was necessary to look outside the limits of the old Submarine Mining Service and to include in the new organization the other services which had grown up for charge of telegraphs, telephones, and machinery, as well as the ordinary fortress work of constructing and repairing fortifications and War Department buildings.

The whole of these services were therefore brought together and a complete new organization evolved on the following lines :—

All officers were to be trained as formerly in the ordinary engineer duties of field and permanent fortification, the repair of barracks, and sanitary services. In addition a certain number of officers each year were to be trained for the special electrical duties, including telephones and other forms of electrical communication.

A considerable number of different classes of mechanists had been introduced up to that time, and these were amalgamated into a few larger groups, leaving one class for all electrical services, which absorbed the special staff for military telegraphs, and one class for all machinery services. The mechanist coxswains had to be reduced, as their vessels were transferred away.

The valuable storekeeping staff was retained and made available for all R.E. storekeeping work. This branch has since been expanded in numbers, with probably great benefit to the works services.

The officers of the Coast Battalion were retained and were employed as before in fortress duties at the various commercial ports.

The N.C.O.'s and men were organized into two classes. One was the ordinary fortress engineer trained as formerly at Chatham ; the other class, after a shorter course at Chatham, went through a special course at the electric-light schools and were then employed on special duties in fortresses. The training of the two classes was sufficiently alike to enable the whole to be on one list for promotion to the higher ranks.

At the small fortresses it was then possible to have only one fortress unit, to which all the officers and men in the fortress were posted.

At the large fortresses where more than one company was necessary the works and electric-light men were kept in separate units.

All fortress units were strictly localized with a station establishment.

These changes could not of course be effected with a stroke of the pen or without some hardship to individuals; but four years' hard work at the War Office and at stations has resulted in a working organization being developed.

The War Office organization was not much affected by these changes. It had already been decided to abolish the Assistant Inspector, and the remaining staff was retained for electrical services. The title of the officer in charge was changed to that of Inspector of Electric Lights, and among other details of reorganization the charge of all R.E. equipment (except railways) was transferred to this branch.

Of the Submarine Mining Schools, those at Portsmouth and Plymouth were much better adapted for teaching defence electric lighting than the one at Chatham. It was therefore decided to close the Submarine Mining School at Chatham altogether and to withdraw the instruction in defence electric lighting from the Electrical School, S.M.E.

Diving was abolished as an Army service and the gear transferred to the Navy. The instruction in instrument repairing in connection with electric lights was divided between the two electric-light schools.

The total number of Regulars to be trained was very little less than formerly, though the length of the course for individuals was reduced owing to the withdrawal of the submarine mining details; on the other hand, the importance of other electrical work in the defences had increased considerably. It was therefore decided to improve the status of the Instructional Staff, so that the appointments could be held by majors and captains.

The Chief Instructor at Portsmouth was made an associate member of the R.E. Committee, and as a good deal of experimental work fell to this station, the Chief Instructor was relieved of the detailed work involved in the command of the company, while retaining the general supervision of all the electrical work in the fortress.

On the whole, it is hoped the reorganized service will have a long life of utility before it.

APPENDIX II.

ALPHABETICAL LIST OF R.E. OFFICERS TRAINED IN S.M., EXCEPT COAST BATTALION AND QUARTERMASTERS.

Name.	Date of Joining S.M.	Special Employment as a Submarine Miner.	Other Employment or Distinctions Active Service is Entered in Italics.
Abney, W. de W.	1871	Early experiments with explosives.	Asst. Instructor in Telegraphy and Chemistry, 1871. Ret Capt., 1881, K.C.B.
Acworth, G. P. A.	1888	Asst. Instructor, Chatham, 1896. Chief Instructor, Chatham, 1901-05.	*S. Africa*, 1899—1900. Ret. Major, 1905, M.A. (Oxon.), Rev.
Addison, G. W.	1873	—	Ret. Lt.-Col., 1899. Sec., R.E. Committee, 1882.
Akerman, C. S. A..........	1898	Temp. Asst. Instr. Brennan Torpedo, 1900-04.	Instructor, R.M. Academy, 1904.
Alexander, A. G.	1881	—	Ret. Col., 1897.
Anderson, R.	1894	—	Died of wounds, *S. Africa*, 1901.
Anderson, S.	1866	Asst. Instructor, Feb., 1866. Asst. I.S.D., 1876-81. I.S.D., 1881.	Died, Major, 1881.
Anstey, T. H.	1877	--	*S. Africa*, 1879. Ret. Col., 1896.
Archbold, F. H. W.	1902	—	—
Armstrong, R. Y.	1871	Early experiments, 1868. Asst. Instructor S.M., 1871. Instructor in Telegraphy, 1876. Inspector S.M. Defences, 1884.	C.B., F.R.S. Ret. Col., 1892. Died 1894.
Bagnall-Wild, R. K.	1895	—	Sec., Mechanical Transport Committee, War Office, 1906.
Bamberger, C. D. W. ...	1904	—	—
Bannerman, Sir A., Bart.	1893	—	*S. Africa*, 1899—1902. Military Attaché, Siege of Port Arthur, 1904. Bt.-Major. General Staff, War Office, 1908.

Name.	Date of Joining S.M.	Special Employment as a Submarine Miner.	Other Employment or Distinctions. Active Service is Entered in Italics.
Barker, G.	1872	Woolwich, 1876–77. Asst. Instructor, 1877–80.	*Egypt*, 1882. *Bechuana*, 1884–85. Sec., R.E. Committee, 1880–82. A.I.G.F., War Office. Inspector, Royal Engineers, 1904–08. Major-Gen., 1907.
Barker, J. S.	1900	—	Drowned, Ceylon, 1904.
Barrow, W. E.	1897	—	—
Baylay, F.	1886	Employed War Office, 1897.	Instructor in Electricity, 1901–06.
Beazeley, G. A.	1892	—	*East Africa*, 1903–04.
Bell, H. L. G.	1895	—	—
Bennet, F. W.	1873	—	*Egypt*, 1882. *Soudan*, 1884–85. Bt.-Major, 1886. Ret. Col., 1901.
Benton, N.W.	1901	—	—
Bigge, G. O.	1889	—	*S. Africa*, 1899—1901.
Bisset, J. S.	1902	—	—
Blandy, L. F.	1896	—	—
Bocquet, R. N.	1904	—	—
Borton, W. N.	1903	—	—
Bowdler, B. W. B.	1894	—	*p.s.c.*
Bowles, F. G.	1878	—	*Soudan*, 1885.
Boyce, E. J. G.	1878	—	Ret. Col., 1907.
Boyd, M. A.	1882	Chief Instructor, Plymouth, 1892–97.	—
Brady, D.	1890	Adjutant, E.E. Vols., 1897—1901.	*S. Africa*, 1902.
Bremner, A. G.	1890	—	*Soudan*, 1896.
Bremner, A. P.	1886	—	Ret. Lieut., 1893.
Bremner, A. D. St. G.	1902	—	—
Brett, W. P.	1885	Inspector S.D. in India, 1904.	Instructor and Professor, R.M. Academy, 1894—1903.
Broadbent, J. E.	—	Early experiments	Ret. Col., 1902. C.B.
Brotherton, T. de la H.	1878	—	*S. Africa*, 1879 *and* 1881, Ret. Col., 1907.
Broughton, T. D.	1894	—	—

Name.	Date of Joining S.M.	Special Employment as a Submarine Miner.	Other Employment or Distinctions. Active Service is Entered in Italics.
Brown, W. Baker	1885	Asst. Instr., Portsmouth, 1892-96. Chief Instructor, Chatham, 1896—1901. Inspector Electric Lights, 1905.	—
Bucknill, J. T.................	1877	Asst. Instructor, 1876. Employed at War Office and Woolwich, 1877-84.	Secretary, Oberon Committee, 1874-76. Ret. Lt.-Col., 1887.
Bulkeley, H. I.	1905	—	—
Burnaby, C. G.	1888	—	*S. Africa*, 1900-02.
Burn-Murdoch, P. R.......	1880	Experimental Officer, 1892-97. Asst. Inspector, 1897—1900.	*S. Africa*, 1900-02.
Butterworth, R. F..........	1897	—	—
Caillard, V. H. P.	1878	—	*Egypt*, 1883. Ret. Lieut., 1883. Knt.
Cameron, M. A.	1877	Employed at War Office, 1878-80.	Ret. Major, 1897.
Campbell, P. H............	1898	Experimental Officer, Brennan Factory, 1904-05.	—
Carden, A. D...	1896	—	Asst. Instructor Electricity, 1900-03. Asst. Supt. Balloon Factory, 1907.
Cardew, A. M.	1901	—	—
Cardew, P.	1876	—	Asst. Instructor Telegraphy, 1878. Instructor in Electricity, 1883-89. Ret. Major, 1894.
Carr, G. A..................	1878	Asst. Instructor, 1885-87. Employed War Office, 1887-88. Chief Instructor, Chatham, 1892-96.	Instructor in Electricity, 1896—1901. *S. Africa*, 1902.
Carter, C. C.	1874	Inspector S.D. in India, 1884-88.	Died in India, 1888.
Caulfeild, St. G. R. S. ...	1889	Chief Instructor, Plymouth, 1905.	—
Chadwick, O.	1866	Early experiments...........	Ret. Lieut., 1873.
Chermside, H. C.	1873	—	*Egypt*, 1882-84, 1885 *and* 1887. *S. Africa*, 1899—1900. G.C.M.G., C.B. Ret. Lt.-Gen., 1907.
Clayton, V. G.	1886	O.C. Submarine Mining Battn., 1886-88.	Ret. Col., 1894.
Close, F. M.	1891	—	Instructor, R.M. Academy, 1899—1904.

Name.	Date of Joining S.M.	Special Employment as a Submarine Miner.	Other Employment or Distinctions. Active Service is Entered in Italics.
Coffin, Campbell...........	1888	—	*p.s.c.*
Coffin, Clifford	1890	—	*S. Africa*, 1900-02. *p.s.c.* General Staff, 1904-07.
Coke, B. E.................	1903	—	—
Collins, C. B.	1888	Asst. Instructor (Brennan), 1897—1901. Chief Instr., Portsmouth, 1901-06.	—
Collins, D. S.	1901	—	*S. Africa*, 1901-02. Officer, R.M. Academy, 1908.
Collings, G. M.	1873	Inspector S.D., India, 1877.	Ret. Lt.-Col., 1883. Died 1889.
Coode, A. M.	1903	—	—
Cowan, J. H.	1878	War Office, 1885	*S. Africa*, 1899—1900. Asst. Director Fortifications and Works, 1908.
Crossman, W.	1876	Inspector S.D., War Office, 1876-81.	Ret. Major-Gen., 1886. K.C.M.G. Died 1901.
Cumming, E. A...	1892	—	Ret. Capt., 1905.
Cunningham, A. B.........	1899	—	—
Daukes, H. F...............	1901	—	Died 1907.
Davy, C. W.	1889	—	*S. Africa*, 1902. Instructor in Electricity, 1906.
Dawes, N. B. E.	1899	—	*Aden*, 1903-04.
Dixon, R. T.	1887	—	Ret. Capt., 1897.
Dobbs, G. E. B............	1905	—	—
Dopping-Hepenstal, L. J.	1881	—	*Egypt*, 1882. Ret. Major, 1907.
Druitt, E.	1880	In charge S.M. Defences, Queensland, 1889-94.	Sec., R.E. Committee, 1894-99.
Dumaresq, A. H.	1891	—	*S. Africa*, 1900-01.
Dumble, W. C.	1894	Adjutant, E.E. Vols., 1903-07.	Ret. Capt., 1907.
Dumbleton, H. N.........	1880	Asst. Instructor, 1885-90. Chief Instructor, Portsmouth, 1895—1900. Inspr. S.D., War Office, 1900-05.	*Soudan*, 1884-85.
Dundee, W. J. D.	1884	—	*India*, 1897-98, also 1908. C.I.E. Bt.-Col.
Durnford, G. E. J.........	1897	Asst. Instructor, Chatham, 1900-05.	—

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Edgeworth, J. A.	1904	—	—
Edmonds, J. E.	1884	—	*S. Africa*, 1900-02. *p.s.c.* General Staff Officer, 1902-08.
Edwards, R. F.	1887	—	Sec., R.E. Institute, 1897—1902.
Evans, C. E.	1902	—	—
Fanshawe, G. L.............	1887	—	Died Malta, 1902.
Featherstonhaugh, A.......	1877	Inspector S.D., India, 1878-82.	Ret. Col., 1893. Died 1902.
Fife, J. G.	1889	—	Ret. Lieut., 1897.
Fisher, A. A'C.	1864	Member Active Obstructions Committee.	*Crimea*, 1855-6. *China*, 1857-60. C.B. Died 1879.
Fisher, J. T.	1903	—	—
Friend, L. B.	1877	—	Sec., R.E. Committee, 1884-89. *Nile*, 1898. Asst. Director Fortifications and Works, 1903-08. Brig.-Gen. Comdg. Coast Defences, Scotland, 1908. C.B.
Garwood, J. R.	1894	Asst. Instr., Portsmouth, 1901-06.	—
Giles, V.	1898	—	*Tibet*, 1903-04.
Gillespie, R. St. J.	1893	—	*Tibet*, 1903-04.
Grant, A.....................	1882	—	—
Grove, T. T.	1900	—	—
Guggisberg, F. G.	1891	—	Director of Gold Coast Survey, 1905—1908.
Haig, H. de H.	1877	Adjutant, S.S.M. Militia, 1887-89.	*p.s.c.* Ret. Col., 1906.
Haig, E. H..................	1889	Asst. Instr., Portsmouth, 1896—1900. Chief Instructor, Plymouth, 1900-05.	—
Halliday, C. O.	1892	—	*India*, 1897-98. Died 1907.
Hamilton, J. E. O'H. ...	1884	Adjutant, Gosport, 1890-94.	—
Harding-Stewart, E.	—	Early employment at War Office.	*S. Africa*, 1879. Ret. Major-Gen., 1883. C.M.G.
Harvey, C. B...............	1894	—	*S. Africa*, 1902.
Harward, F. E.	1894	—	*S. Africa*, 1899—1900. *Somali*, 1903. Died 1903.

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Hawker, E. C. T.	1879	—	Died 1887.
Hawkins, W. F.	1878	—	Asst. Instructor Electricity, 1889. *Soudan*, 1884-85. *S. Africa*, 1899–1900. C.M.G. Ret. Col. 1907.
Hepper, A. W.	1899	—	*S. Africa*, 1899–1900.
Heneage, F. W.............	1874	—	*S. Africa*, 1879. Died 1881.
Heron, T. B.	1903	—	—
Hill, R. C. R.	1900	—	—
Hodder, W. M.	1884	—	—
Hogg, P. G. H.	1899	—	*S. Africa*, 1899–1900.
Home, G. L.	1889	—	—
Hood, Hon. F. G.	1901	—	—
Hordern, C.	1903	—	*S. Africa*, 1900-02.
Iles, F. A.	1895	—	—
Jackson, L. M.	1899	—	—
Jeffreys, F. V...............	1882	—	*China*, 1900.
Jekyll, H.	1868	—	*Ashanti*, 1873-74. K.C.M.G. Ret. Col., 1901.
John, C. L..................	1901	—	—
Johnson, J. F. W.	1892	—	Died, India.
Johnson, P. W.	1905	—	—
Jones, L.	1884	—	—
Jones, D. C.	1898	—	—
Kelsall, H. W.	1890	—	—
Kent, H. V.	1885	Asst. I.S.D., 1902-04.	
Knight, H. P.	1875	Adjutant, S.S.M. Militia, 1880-87.	Ret. Col., 1903.
Laffan, J. de C.	1887	—	Ret. Major, 1906.
Lambert, D. R.	1887	—	Died, Ceylon, 1892.
Langman, J. A.	1898	—	—
Laurence, G. C. L.........	1890	—	—
Lawrie, W. G................	1885	Asst. Instructor, 1890-95...	*S. Africa*, 1902.
Lees, W. E..................	1891	—	—
Leslie, G. A. J.	1889	—	*Tirah*, 1897. Bt.-Major.

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Leverson, G. F.	1878	—	*British Military Attaché, Spanish-American War,* 1898. *S. Africa,* 1899—1902. Chief Engineer, Malta, 1908. *p.s.c.*
Lloyd, F. L.	1887	Asst. Instructor, Plymouth, 1895-97. Chief Instructor, Plymouth, 1897—1900.	*S. Africa,* 1901-02. Ret. Major, 1905.
Loring, E. M.	1888	—	Died, Hong Kong, 1892.
Le Mesurier, H. G.	1894	—	—
MacAdam, W.	1886	Supt. Brennan Torpedo Factory, 1896—1902.	—
MacDonnell, A. C.........	1877	—	*Afghan,* 1878-79. *Soudan,* 1885. Ret. Col., 1907.
MacDonogh, G. M. W....	1886	—	Brigade-Major, S.M.E., 1899 — 1903. *p.s.c.,* General Staff, 1906.
Macfie, W. C...............	1895	—	*S. Africa,* 1899 — 1902. Asst. Inspr., R.E. Stores, 1906.
Mackintosh, E. E. B. ...	1900	—	—
Macrory, R. M.	1895	—	—
Malan, L. N.	1898	—	*Tibet,* 1903-04.
Malcolm, E. D.	1870	Inspector S.D., War Office, 1882-84.	*Mutiny,* 1857-58. Instructor in Telegraphy, 187.-76. C.B.
Marryat, J. R.	1905	—	—
Mascall, F.	1866	Early experiments...........	C.R.E., Portsmouth, 1896—1901.
McCausland, M. E.	1901	—	Died 25 Dec., 1904.
McClintock, R. L.........	1895	—	*West Africa,* 1897-98. *S. Africa,* 1899—1902. Bt.-Major. D.S.O.
McEnery, J. A.	1898	—	*Tibet,* 1903-04.
Meyricke, E. G.	1896	—	Died at Aldershot, 30 Nov., 1905.
Meyricke, R. E.	1896	—	*S. Africa,* 1899—1900. Died at Maritzburg, Natal, 8 March, 1900.
Middlemass, J. C.	1877	—	Ret. Col., 1907.
Mildred, S.	1893	—	—
Mills, D. A.	1881	—	—

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Molesworth, P. B.	1888	Early experiments	Ret. Major, 1906. Died 25 Dec., 1908.
Moore, R. F.	1870	Early operations with wrecks.	Ret. Major, 1892.
Moore, H. O'H.	1896	—	—
Mould, C. F.	1885	—	Died, London, 1901.
Noble, W. J. W.	1900	—	—
Noble, N. D.	1900	—	—
O'Brien, D.	1874	War Office and Woolwich, 1874-76.	Died, Eltham, 1898.
O'Donel, M. B. H.	1892	—	—
Ogle, A. B.	1903	—	—
Ommanney, M.	1864	Early experiments	Ret. Capt., 1878. G.C.M.G., K.C.B., I.S.O.
Ord, W. St. G.	1871	—	Ret. Capt., 1882.
Osborn, O. E.	1894	—	Died, Malta, 1898.
Osborne, G. F. F.	1896	—	—
Owen, S. L.	1893	—	*S. Africa*, 1899-02.
Owen, A. L.	1903	—	—
Painter, A. C.	1885	—	—
Palmer, W. L.	1890	Instructor Brennan School, 1901-05.	—
Paterson, H. A. L.	1880	—	—
Penrose, C.	1878	Asst. I.S.D., 1891-96. I.S.D., 1896-97.	*S. Africa*, 1879. *China*, 1900. Chief Engineer, Portsmouth, 1906.
Phillpotts, B. S.	1896	—	—
Piggott, F. S. G.	1902	—	—
Pilcher, A. J.	1888	—	—
Ponsonby, R. G.	1899	—	—
Porter, M. T.	1902	—	—
Prince, P. E.	1902	—	—
Pym, E. H.	1895	—	—
Pyne, W. M.	1891	Asst. Instr., 1897—1902. Exptl. Officer, 1902-04.	—
Quill L.	1881	—	Died, Malta, 1888.

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Rainsford-Hannay, F. ...	1877	War Office and Woolwich, 1885-89. Inspector S.D., War Office, 1898—1901.	Chief Engineer, Ireland, 1906-07. Comdt., S.M.E. 1907-08. Director Fortifications and Works, 1908. Brig.-Gen.
Rainsford-Hannay, A. G.	1903	—	—
Ramsay, J.	1875	Portsmouth Experiments, 1878-80.	Ret. Capt., 1881.
Randolph, A. H.	1881	Asst. I.S.D., 1900-02	*Afghan*, 1878-80. Ret. Lt.-Col.
Rawson, H. E.	1875	—	Sec., R.E. Committee, 1889-1904. *S. Africa*, 1899-1902. Bt.-Col., C.B. Chief Engineer, S. Africa and Northern Commands, 1905-08.
Renny-Tailyour, H. W....	1873	Temp. Asst. Instructor, 1875-77.	Ret. Col., 1899.
Reynolds, F. R.............	1879	Asst. Instructor, 1888-91...	Ret. Col., 1908.
Rhodes, E. F...............	1875	War Office and Woolwich, 1882-85.	Ret. 1892. Died, 1907.
Rice, S. R.	1881	Actg. I.S.D., India, 1888-89	*S. Africa*, 1899—1902. Bt.-Lt.-Col.
Ridout, D. H...............	1886	—	*S. Africa*, 1900-02.
Roberts, H. B.	1882	Asst. Instructor, 1892-96...	Ret. Major, 1906.
Robertson, F. W.	1897	Asst. Instructor, Plymouth, 1902-06.	—
Rolland, A..................	1892	—	*China*, 1900.
Ruck, R. M.	1874	Asst. Instructor, 1881-85. Asst. I.S.D., 1886-91. Inspector, S.D., War Office, 1891-96.	Depy. I.G.F., 1902-04. Director Fortifications and Works, 1904-08. Maj.-Gen. in Charge Administration Eastern Command, 1908.
Ruck, O. E.	1878	—	*S. Africa*, 1881. Ret. Col., 1908.
Rundall, C. F.	1893	Supt. Brennan Torpedo Factory, 1904-07.	—
Rundle, F. P.	1892	—	*India*, 1897-98.
Russell, B. B.	1881	—	*India*, 1890. *Chitral*, 1895.
Scott, A. C.......	1893	—	*Tirah*, 1897-98. *S. Africa*, 1901-02.
Scott, P. G......	1871	First Subaltern with S.M. Company.	Asst. Instructor, Tels. Died, 1878.

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Seaman, E. C.	1888	Asst. Instructor (Brennan), 1890-97. Supt. Brennan Factory, 1902-04.	—
Sewell, J. W. S.	1893	—	*S. Africa*, 1899—1902.
Shellabear, W. G.	1884	Adjutant, Eastern Battn., 1888-90.	Ret. Lieut., 1890. Rev.
Sherrard, A. B.	1904	—	—
Simmons, G. Le Breton ..	1886	Expmtl. Officer, 1896—1902. Chief Instructor, Portsmouth, 1906.	*Hazara*, 1898.
Simon, M. S. L....	1897	—	—
Skinner, T. C.	1886	—	—
Slater, M. J.	1886	Adjt., Gosport, 1889-90.	*Afghan*, 1878-80. Died Jamaica, 1897.
Smith, G. E.	1890	—	*S. Africa*, 1901-02. Director of Survey, East Africa. C.M.G.
Speranza, W. S.	1886	—	—
Stace, R. E.	1902	—	—
Stevens, A. C. J.	1896	Instr., Plymouth, 1905 ...	*China*, 1900.
Stockley, G. W.	1872	First Comdg. Officer, 4th Co. Oberon Experiments.	Ret. Col., 1891.
Stotherd, R. H.	1866	Supt. Schools, 1866-71. In charge S.D. Branch, War Office, 1873-76.	Director of Ordnance Survey, 1883-86. Ret. Major-Gen., 1886. C.B. Died 1895.
Stuart, A. M.	1881	War Office, 1898-99. Inspr. S.D., India, 1899—1904.	Asst. Instructor Electricity, 1889-94. Inspector, R.E. Stores, 1894-98. *Soudan*, 1884-85 and 1885-86. Comdr. Coast Defences, 1908.
Swinton, A. J.	1903	—	—
Taylor, L. R. J. W.	1897	Tempy. Asst. Instructor, Brennan School, 1904-05.	—
Taylor, M. G.	1902	—	—
Thompson, W. M.	1891	—	—
Thomson, C. B.	1895	—	*S. Africa*, 1896. *S. Africa*, 1899—1902. Bt.-Major.
Thorp, G.	1901	—	—
Tighe, C. D. C.	1893	—	Died London, 1898.
Tower, G. A.	1877	—	*Soudan*, 1884-85. Ret. Col., 1906.

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Trench, A. H. C.	1904	—	—
Trew, R. J. F.	1901	—	—
Tudor, E. A. T..........	1886	—	—
Tyler, H. E.	1877	Inspr. S.D., India, 1894-99	Inspector R.E. Stores, 1889-94. Ret. Col., 1906.
Van Straubenzee, A. H....	1884	—	Instructor, R.M. College, Canada, 1886-93.
Versturme-Bunbury, C. H.	1888	—	—
Vickers, H. M.	1889	—	Ret. Lieut., 1891.
Vidal, W. Sealy	1881	Experimental Officer, 1890-92. Chief Instr., Portsmouth, 1892-95.	*Egypt*, 1882. *Soudan*, 1884-85 *and* 1885-86. Died Teneriffe, 1896.
Von Donop, P. G.	1874	Inspr. S.D., India, 1889-94	*Soudan*, 1884-85. Ret. Lt.-Col., 1902.
Von Hugel, N. G.	1886	—	*S. Africa*, 1899—1902.
Wade, H. M. St. A.	1888	—	Inspector R.E. Stores, 1898—1901. Ret. 1902. Died Exmouth, 1903.
Wait, H. G. K.	1891	—	Inspector, R.E. Stores, 1901-06.
Walker, A. R................	1898	—	—
Walker, R. S.	1892	—	*S. Africa*, 1900-02. Chief Instructor, R.M. Academy, 1904.
Walker, R.	1897	—	—
Watkins, P. S.	1899	Instructor, Portsmouth, 1906	—
Watson, C. M.	1871	War Office and Woolwich, 1872-74.	*Egypt*, 1882. Bt.-Major. Ret.Col., 1902. K.C.M.G., C.B.
Webber, O. T. O'K.	1891	—	*S. Africa*, 1900.
Weekes, H. W.	1890	—	*Chitral*, 1895.
Whitmore, M. D.	1873	Commanding Eastern Battn., 1887-90.	*Egypt*, 1882. Died, Deal, 1892.
Wingfield-Stratford, C. V.	1876	Adjutant, S.M. Battn., 1884-89.	Chief Engineer, Ireland, 1907. Brig.-Gen.
Winterbotham, H. St. J. L.	1899	—	*S. Africa*, 1899—1900.
Wolski, F. R. de	1869	—	C.R.E., Thames District, 1900-03.
Wood, C. K.	1874	—	*Soudan*, 1884-85. *S. Africa*, 1899—1900. Bt.-Col.

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Wood, J. C. I.	1902	—	—
Woodroffe, A. J.	1893	—	*West Africa*, 1901–02 *and* 1905–06.
Yates, A. S. J.	1903	—	—
Young, E. G.	1888	—	*S. Africa.* Died, fever, 1900.

NOTE.—In addition to the above, a considerable number of officers went through courses of instruction about 1878 to 1880, but never actually took part in submarine mining operations. Also various officers were attached to the *Hood* or the Submarine Mining Battalion at Chatham for military duty without any special submarine mining training. All of these are omitted from the list.