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Publication Number 2

THE NORTHERN BARRAGE AND OTHER MINING ACTIVITIES

Published under the direction of
The Hon. JOSEPHUS DANIELS, Secretary of the Navy

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

REAR ADMIRAL JOSEPH STRAUSS, U. S. NAVY,

Commander of the American mining operations in the North Sea during the World War.

U.S. Office of Naval Records and Library.

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ERRATA

Page 125, after paragraph 2 add: The following submarines were sunk in the Northern Mine Barrage:

Area	Submarine	Date
B	U-92	September 9, 1918
B	U-102	September -- (Probable)
A	U-156	September 25, 1918
B	UB-104	September 19, 1918
B	UB-127	September -- (Probable)
A	UB-123	October 19, 1918

Sources: The Submarine Warfare by Micholson and British Submarine Losses Return 1919.

Page 124, paragraph 3, 1st line: change last word to one. 5th line: strike out sentence beginning "The other, the UB-22,etc."

Page 125, paragraph 1, 4th line: change U-123 to read UB-123.

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THE NORTHERN BARRAGE AND OTHER MINING ACTIVITIES.

Publication No. 2, Historical Section, Navy Department.

ERRATA.

Page 48, line 14: After the word "dimensions" strike out "34" and insert *33*.

Facing page 80, photographs: In captions for photographs of U. S. S. Baltimore and U. S. S. San Francisco, strike out "North Atlantic Fleet" and insert *U. S. Mine Force.*

Page 87, line 8: After the word "miles" insert the word *in.*

Page 105, line 4: Strike out the word "proceed" and insert the word *proceeded.*

Page 140, line 43: Strike out the word "has," and after the word "issued" insert (*Up to July 18, 1919*).

NOTE: These Mine Warnings to Mariners are still being issued. Up to February 3, 1921, 413 have been received by the Hydrographic Office of the Navy Department.

Page 141, line 2: After the word "date" insert *period.*

Page 141, lines 2, 3, and 4: Strike out the words "and are published herewith in explanation of the policy that was to be carried out" and insert in lieu thereof *The explanation of the policy to be carried out is illustrated in the two charts of a later date which accompany this publication.*

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TABLE OF CONTENTS.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

CHAPTER XVII.

CHAPTER XVIII.

CHARTS IN POCKET.

LIST OF ILLUSTRATIONS.

PREFACE.

The mining operations herein described naturally involve two distinct functions:

(*a*) The design and manufacture of the mines together with all the accompanying materials and their transportation to Scotland.

(*b*) The most difficult and hazardous sea operation of building the barrage.

The first of these functions was performed by the Bureau of Ordnance of which Rear Admiral Ralph Earle was the chief.

The second of these operations was conducted by Rear Admiral Joseph Strauss.

This report is a compilation from the exhaustive report made by Rear Admiral Strauss, together with that made by Rear Admiral Ralph Earle, the two with other data being combined by Commander Simon T. Fullinwider, and edited in the historical section of the Navy Department.

Referring to the accompanying charts of the mine areas of the world, it is realized that the first impression is that very little of the sea was safe in the European waters and the Mediterranean. While this is more or less true, a careful reading of the meaning of the various forms of shading will give a more correct idea of the actual degree of danger that existed.

C. C. MARSH,
Captain, U. S. N. (Ret.),
Officer in Charge, Historical Section, Navy Department.

DECEMBER 12, 1919.

THE NORTHERN BARRAGE.

Chapter I.

CONCEPTION AND INCEPTION OF THE NORTHERN BARRAGE[1] PROJECT.

The northern barrage was one of the most important naval projects carried out by the United States during the war. To appreciate the importance of the barrage as a factor in the prosecution and winning of the war, one must consider the general military situation as it existed in April, 1917, when the United States threw her weight into the scales with the Allies. There was every reason at that time for a pessimistic view of the situation. The military situation on the west front was practically a stalemate. The French and British forces appeared to have a slight advantage over the enemy, having made small gains here and there; but they plainly had little or no prospect of obtaining an early military decision. The Italians were holding their own, but with no prospect of decisive victory.

On the east front the Russians were holding for the time being, but there were ominous indications that the newly established revolutionary government would be unable to overcome internal dissensions and that the Russian power might crumble at any time.

In the Balkans the Allies had insufficient force, apparently, to prosecute an offensive campaign; and the growing submarine menace in the Mediterranean seriously threatened the lines of communication by which this force was sustained. In fact, there was grave danger, especially in view of the pro-German attitude of the then Greek Government, that the allied force based on Saloniki would have to be withdrawn and the entire Balkan Peninsula given up to the Central Powers. In Asiatic Turkey the British were making slow progress in Mesopotamia; but it was doubtful whether victory there would have any material effect on conditions in Europe.

In short, at the time of the entrance of the United States into the war, there was no prospect of victory over the Central Powers unless and until heavy American forces could be sent to Europe to turn the scale. America was not ready, and could not be expected to create and equip an adequate army within at least one year, or probably two.

[1] This barrage was known in the United States as the North Sea barrage; but, since it was termed by the British the northern barrage, and since there were other shorter and minor mine barrages planted in the North Sea by the British, the title northern barrage will be used in this narrative.

The sending of an American army to France would necessitate the safeguarding of the lines of communication across the Atlantic; in other words, the result of the war was seen to hang upon whether or not the Allies and the United States could obtain and hold the mastery of the sea. As in all wars in which maritime nations have been engaged, sea power was to prove the decisive factor. The British Fleet and the naval forces of the United States and other associate powers were supreme on the surface of the sea, and had it not been for the submarine there would not have been the slightest occasion for doubt of a quick and satisfactory outcome of the war; but the surface fleets were, as a matter of fact, almost impotent in the face of the submarine menace. The German Government concentrated early in the war on the development of the submarine and built these vessels in large numbers, with the purpose, as it turned out, of waging a ruthless war on shipping and thereby bringing Great Britain and her Allies to terms. Generally speaking, the German High Seas Fleet was kept safe at home, while the British Grand Fleet and other allied heavy naval forces, having no enemy to meet on the high seas, were compelled to wait at their well protected bases until the German Fleet should put to sea. Thus there was little naval activity beyond the submarine warfare waged by the Germans against merchant shipping, and the allied anti-submarine campaign.

The Germans embarked on the policy of sinking merchant ships without warning in December, 1916; and in February, 1917, unrestricted submarine warfare on merchant shipping was formally announced. While the sinking of merchant tonnage had been very considerable up to this time, it rapidly increased until it reached a high point in April, 1917, of 800,000 tons a month. The average for the first six months of that year was 600,000 tons a month, or about 7,000,000 tons a year. It was a plain mathematical deduction that if this condition were permitted to continue, it would assure a victory for the Central Powers within a year, since the diminished merchant fleet of Great Britain and the Allies could not possibly stand this tremenduous loss and meet the requirements of transportation necessary to the successful prosecution of the war.

Soon after the United States entered the war it became a settled policy of our Government to send a large force of troops to reinforce the French and British on the west front. The increasing submarine menace gravely complicated the problem of transporting our troops and their supplies, and every known method of hunting out and destroying submarines was given careful consideration by the Navy Department. Aside from the possible heavy loss of life, due to the sinking of American transports by enemy submarines, there was the moral effect of such sinking to be considered; it might react most

unfavorably on the morale of the entire American Nation and correspondingly cheer the German public.

It became the general policy of the Navy Department to employ every promising means of destroying enemy submarines, and not to be content to rely on any one means to the exclusion of others. The means which proved successful and which were developed, in cooperation with our Allies, to the utmost included the following:

(*a*) Arming of merchant vessels with guns manned by naval gun crews.

(*b*) Sending vessels in convoys through the danger zones protected by destroyers and other suitable naval vessels.

(*c*) "Hunting groups" of vessels of various types equipped with "listening apparatus."

(*d*) Aerial patrol by sea planes and "blimps" armed with depth bombs.

(*e*) Arming of destroyers and other suitable craft with an unlimited supply of depth charges.

(*f*) Mining of waters habitually traversed by enemy submarines.

The first important anti-submarine plan to give encouraging results was the convoy system, adopted in July, 1917. This plan had the one serious defect of slowing down shipping, since in a convoy of, say 20 or 30 vessels, the speed of the convoy was reduced to that of the slowest ship; but following the adoption of this plan the average loss fell to about 450,000 tons a month. The losses were principally from slow convoys composed of relatively slow-speed cargo vessels. The losses from fast convoys made up of transports and other craft having a speed of more than 12 knots were comparatively small; and the effectiveness of the system was finally demonstrated by the fact that no troop ships in American convoys were lost during the war. However, the loss of 450,000 tons of shipping a month, or even a much smaller loss, would have proved fatal to the allied cause if permitted to continue; and additional measures were imperatively necessary.

The allied powers were in a very difficult position and were not prepared to quickly put into effect adequate measures against the entirely novel and unexpected form of submarine warfare instituted by the enemy. So far as the United States was concerned, whatever offensive or defensive measures were decided upon, the procurement of the necessary material therefor would take valuable time. In short, the Navy was not prepared for and could not perform its proper functions until after adequate numbers, or quantities, of destroyers, chasers, guns, mines, depth charges, etc., could be built or manufactured.

Taking the case of mines alone, there were on hand in April, 1917, approximately 5,000 mines of a type which was comparatively

unsuitable for anti-submarine operations. To show the inadequacy of this supply, it may be stated that the British were using about 7,000 a month and were endeavoring to increase their output to 10,000 a month. Also, the British had found from their own experience that the type of mine possessed by the United States (the Vickers-Elia) was not well suited for the peculiar type of mining in hand and had changed to a new type—a horn mine resembling the German and Russian mines.

Not until after the United States entered the war did the British and other allied Governments furnish us with important military information; but as soon as we were permitted to avail ourselves of their war experience the Bureau of Ordnance decided that it would be desirable to provide at least 100,000 mines and that these must be of a type more suitable for anti-submarine operations than any then in existence. In other words, it devolved upon that bureau to develop a new design of mine and to arrange for its manufacture at the rate of approximately 1,000 a day, or four and two-tenths times the production that Great Britain had succeeded in reaching. The reasoning leading to this decision is given below at some length.

The Bureau of Ordnance, even before the United States entered the war, had made a close study of the general conditions, particularly with reference to possible measures to be taken to counteract the submarine peril. The mine section of the Bureau of Ordnance, as a result of many conferences on this all important subject with the Chief[2] and Assistant Chief of Bureau and also section chiefs, suggested the measures that could be taken by the United States in a memorandum under date of April 15, 1917, a partial copy of which is appended. This memorandum dwelt upon two principal propositions: First, the protection of merchant vessels by means of cellular construction and "blisters"; and second, antisubmarine barrages inclosing the North Sea and the Adriatic. Obviously, it was impossible to consider seriously any proposition to close German harbors as long as the enemy had complete control of his own waters. The next best thing to "closing the holes" was, of course, to close the North Sea by means of a barrage restricting the operations of enemy submarines to the North Sea and preventing their getting into the Atlantic and interfering with the lines of communication between the United States and Great Britain and France. The proponents of this plan freely admitted that such a barrage probably could not be made completely effective, but insisted that even if it were only partially effective it would win the war.

[2] At this time, Rear Admiral Ralph Earle, U. S. Navy, was chief of bureau, Capt. T. A. Kearney, U. S. Navy, the assistant chief of bureau, and Commander S. P. Fullinwider, U. S. Navy (retired), the chief of the mines and net section, while Lieut. Commander T. S. Wilkinson, jr., U. S. Navy, was chief of the experimental section

The memorandum was written mainly with a view to crystallizing opinion within the bureau and furnishing a basis for discussion by officers of the bureau with others concerned in the design and procurement of material for increased naval activities.

Within the Bureau of Ordnance practically all officers who would be concerned with such a project quite agreed on the principle that the enemy submarine should be contained by means of such a barrage, though the type of barrage and its location were for a considerable period matters of doubt. The concensus of opinion, however, was that the barrage should extend from the east coast of Scotland to the Norwegian coast. This, together with a short barrage across the Dover Straits, would shut off access to the Atlantic, or at least make the continued operations of enemy submarines exceedingly hazardous and unprofitable.

The proposal to construct a barrage 250 miles long was so novel and unprecedented from every practical viewpoint that it was realized at the time that it would be difficult to obtain a prompt decision without considerable preliminary propaganda within the department. Time was regarded as the supreme factor in the situation, as every day saw the loss of many priceless ships and cargoes.

On April 17 the department cabled to Admiral (then Rear Admiral) W. S. Sims, in command of United States naval forces in European waters, directing him to report on the practicability of blockading the German coast efficiently in order to make the ingress and egress of submarines practically impossible. He, in answer, stated that this, of course, had been the object of repeated attempts by the British navy with all possible means and found unfeasible. Failure to shut in the submarine by a close blockade, using mines, nets, and patrols in the Bight and along the Flanders coast, focussed attention of the department upon plans for the alternative of restricting the enemy to the North Sea by closing to him the exits through the channel and the northern end between Scotland and Norway, as proposed by the Bureau of Ordnance. These are outlined in a memorandum of the Office of Operations dated May 9, 1917, which was to be submitted for the advice and comment of the British Admiralty with its valuable anti-submarine experience. It was noted that, in working up any plan, the whole field of operations was to be considered primarily with a view to attacking the submarine under water as well as on the surface. It was stated that the entrances to the North Sea, while very broad and presenting immense difficulties, came within the bounds of possibility of control. Estimating the cost of gaining this control and confining enemy submarines within the North Sea to be $200,000,000, or perhaps twice that sum, there was no doubt that the United States would devote whatever amount it was worth if the purpose was to be accomplished. This was proposed to be done by establishing a

barrage of nets, anchored mines, and floating mines, to operate from 35 feet to 200 feet below the surface, which, while safe for surface craft, would bar a submerged submarine, while patrols could deal with those running on the surface.

Commenting on this, the Admiralty, who had apparently considered the United States proposals to particularly advocate the extensive use of nets, replied on May 13:

> From all experience Admiralty considers project of attempting to close exit to North Sea * * * by method suggested to be quite unpracticable. Project has previously been considered and abandoned. The difficulty will be appreciated when total distance, depths, material, and patrols required and distance from base of operations are considered.

It was the British experience that nets failed in their purpose on account of the possibility of cutting them; mine nets, when located, were avoided or run over; all were difficult to maintain in place and required too many patrol vessels to watch. Mine barrages were not considered wholly effective unless maintained by patrols at all points. Considering the use of such a barrage from Norway to Scotland, patrols could not be properly protected on such a long line, because the defense would be stretched out in a long and locally weak line, and therefore subject to enemy raids in sufficient force to break through the patrol, cut nets, and sweep mines, and so clear a passage for the submarines. If protected with heavy vessels, these would be exposed to the German policy of attrition with torpedo attack. In short, as concluded by Admiral Sims in his report to the department on May 14, 1917, "Bitter and extensive experience has forced the abandonment of any serious attempt at blockading such passages."

It is noteworthy that the attitude of the British Admiralty and of Admiral Sims was not favorable to the further consideration of the North Sea barrage project; but, notwithstanding this, the proponents of the project, i. e., the officers of the Navy Bureau of Ordnance, redoubled their efforts to secure its adoption, feeling that the result of the war depended upon it more than upon any other possible measures.

From early in March until the latter part of July, 1917, the mine section of the Bureau of Ordnance made an intensive study of many types of barrage, among them the submarine trap and indicator nets which had been used by the British. Most of the plans considered were devised within the bureau, but in addition a very large number of inventions and suggestions from private sources were studied. Unfortunately, practically all inventions or ideas emanating from nonprofessional sources were based on incomplete knowledge of fundamental conditions and requirements. Their shortcomings may be expressed briefly by saying that they were based on mill-pond conditions, whereas the waters in which such a barrage as that under con-

sideration had to be planted and maintained were subject not only to very adverse weather conditions, but also to the activities of the enemy naval forces, which, up to this time, had displayed great initiative and resourcefulness.

The types of barrage studied were of three principal classes: First, nets and entanglements; second, nets in combination with mines or bombs; and third, mines alone. The possibility of employing nets or entanglements alone was abandoned early, inasmuch as the war experience of the British indicated that it was exceedingly difficult to plant and maintain nets of sufficient weight and strength to be of any material value, and because of the depth of water in which the proposed barrage must be laid was quite prohibitive. The quantity of wire rope required was prohibitive in the time available.

Nets in combination with mines or bombs were open to the same criticism, with the additional point that such material would be very difficult and dangerous to handle and the planting would be too slow. It was finally decided that mines offered the only practicable solution, and since no mine then in existence, either in America or abroad, was suitable for the project, mainly owing to the excessive number required, it became necessary for the bureau to design a mine especially adapted to the purpose. A discussion of the evolution of the mine which was finally adopted will follow. It is only necessary to say here that the novel principle of the firing gear of the new mine was discovered in April, 1917, but was not brought to a state of development warranting its adoption until the latter part of July, 1917.

While from the first the new firing mechanism showed great promise, the officers responsible for its development felt that it would be unwise to place too great reliance on it before it had been thoroughly tested out, and therefore studies of other means of forming a barrage were continued without cessation up to the day that the new mine was adopted. As late as July 15, 1917, a memorandum prepared by the mine section was submitted to the Chief of the Bureau of Ordnance suggesting mines in combination with nets. The idea was to have a barrage of overlapping light steel wire nets, about 200 feet square, each net carrying two mines, one attached at the top of the net to be a mine with a hydrostatic firing mechanism, and a second, attached to the center of the net, to have a firing mechanism actuated by a propeller in such manner that a submarine carrying away the net would tow the mine and explode it after a short distance. The hydrostatic mine was intended to explode in the event that the submarine submerged it to a certain depth. It is needless to go into details regarding the construction of this net and the designs of the mines, since nothing ever came of it. The plan was submitted to a board, but during the board's consideration of the project information

was received of the latest test of the new mine-firing device, which was so favorable that further discussion of the plan before it seemed useless, and the matter was dropped with the understanding that the bureau would concentrate on the development of the new mine, which was thereafter to be known as the Mark VI (up to this time, during its experimental stage, it had been known as the type "X" mine).

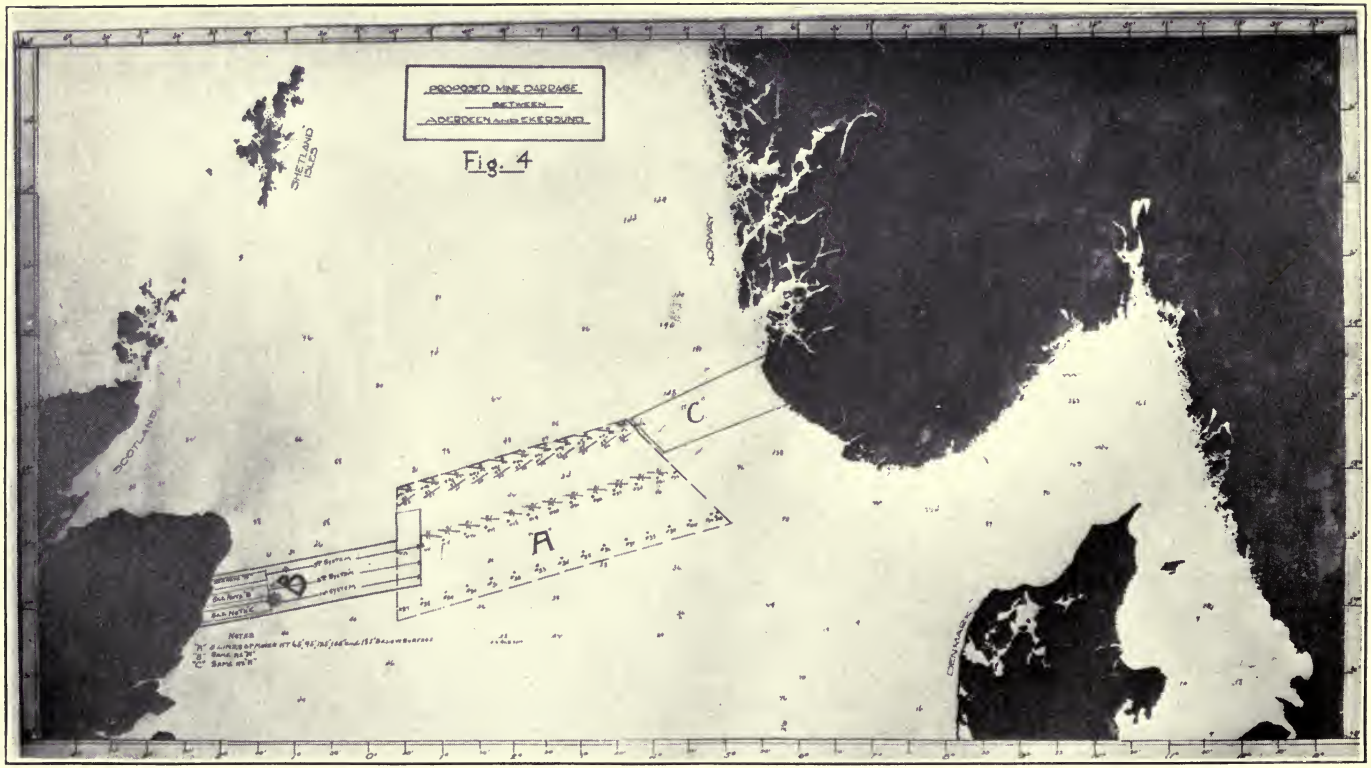
In the early days of the mine barrage project, very little official correspondence took place in the matter, principally for the reason that it was desired to keep the matter a profound secret, since it was probable that any type of mine produced would sooner or later bring about methods of counteracting it. It was felt that if information concerning it could be kept until the material had been produced and placed in use, the enemy would not have time to devise protective methods against it.

A decision in the premises favorable to the mine barrage project was daily becoming more imperative in order to accomplish the laying of the barrage during the best weather of 1918; and, therefore, the bureau had prepared by Commander S. P. Fullinwider, U. S. Navy, chief of the mines and net section, a second memorandum, dated June 1, 1917, which bearing a strong favorable indorsement by the Chief of the Naval Bureau of Ordnance, was submitted to the Chief of Naval Operations, this memorandum recommending certain projects for the future conduct of the war and laying particular stress upon the necessity of the northern barrage as being a most promising offensive operation. In fact, the President had addressed the officers of the battle fleet and stated that, as it was nigh impossible to destroy hornets (i. e., German submarines) after they had escaped from their nests, these hornets must be confined to their nests, or destroyed before reaching the vast wastes of the ocean.

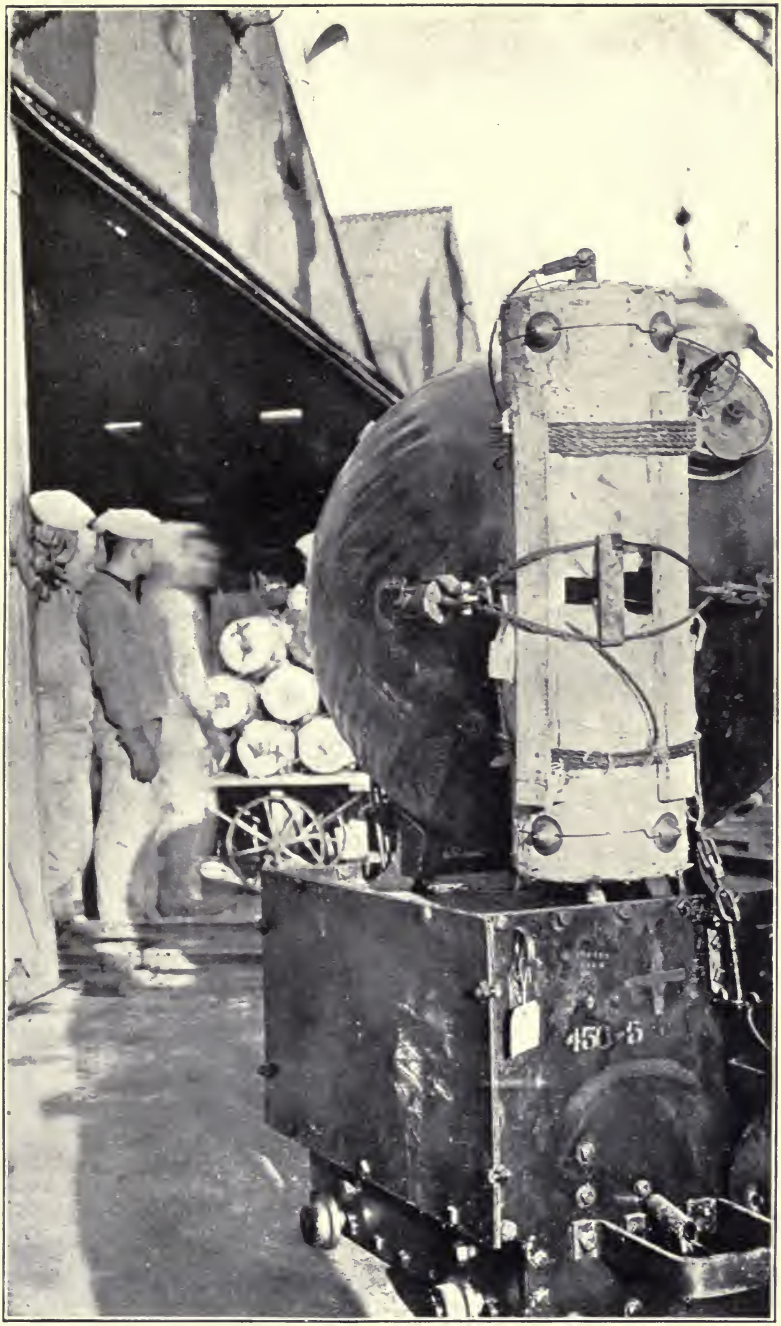
Realizing that it is difficult to obtain quick action on a novel scheme of such magnitude as the one under discussion, and especially in view of the unfavorable attitude shown by the British, the chief of the mine section, as a representative of the bureau, departed from the policy of secrecy to the extent of discussing the as yet indefinite plan with several officers who were in a position to further the scheme, notably with a member of the general board, with an officer close to the President, and with representatives of the Office of Naval Operations. He also discussed the matter with Commander C. D. C. Bridge, a British officer then officially visiting this country, who was shortly to return to London. While the type of mine to be used had not yet been developed, it was important to see to it that the idea of a northern barrage should be accepted as a sound and indispensable measure to defeat the enemy submarine. The Bureau of Ordnance, from the first, took the attitude that if the idea of such a

ADMIRAL HENRY T. MAYO, U. S. NAVY, COMMANDER IN CHIEF U. S. ATLANTIC FLEET, AND REAR ADMIRAL JOSEPH STRAUSS.

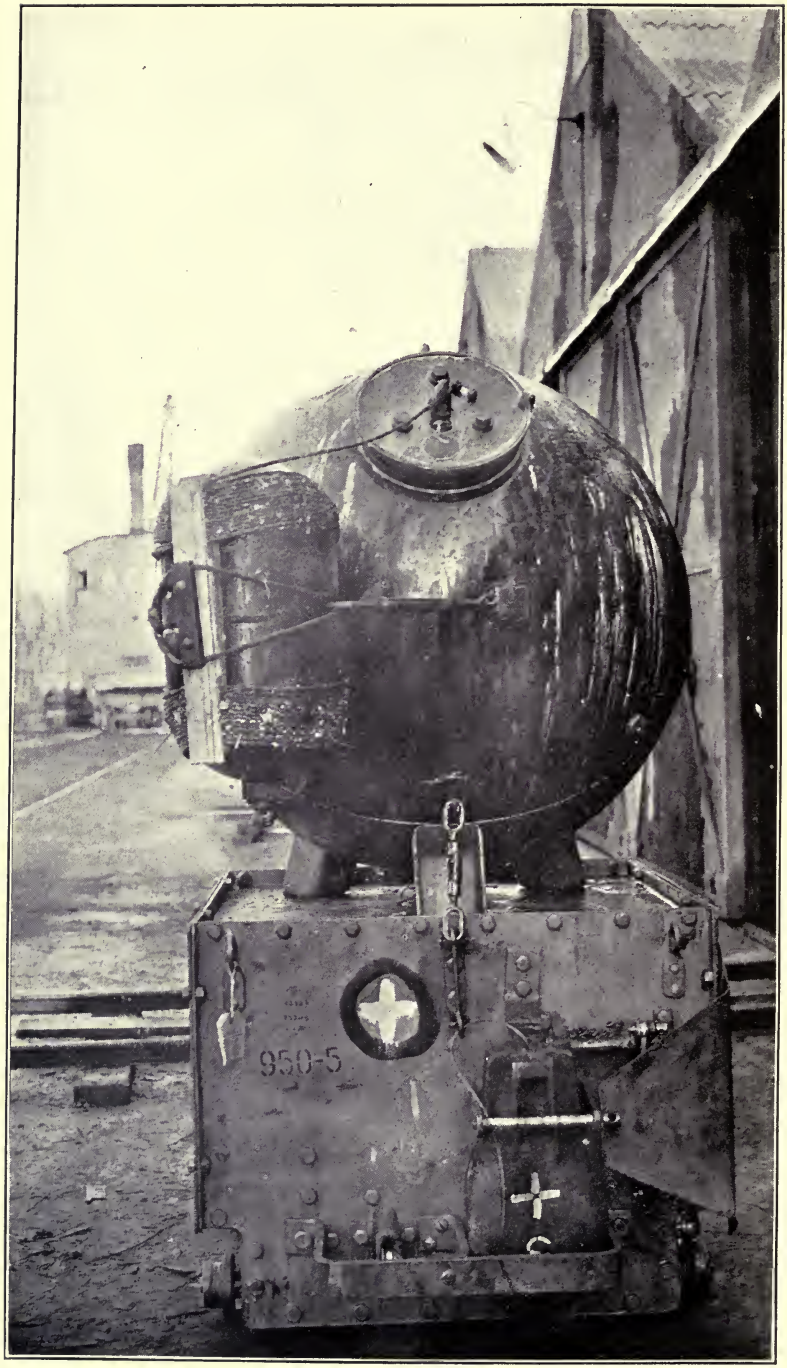
(Page 23.)



PHOTOSTATIC CHART, SHOWING PLAN OF PROPOSED MINE BARRAGE BETWEEN ABERDEEN, SCOTLAND, AND EKERSUND, NORWAY.
(Page 31.)



MARK VI MINE WITH SINKER, FITTED WITH BALSA FLOATS FOR PLANTING IN SHALLOW DEPTHS. (Page 42)



MARK VI MINE FITTED WITH D-4 FLOAT FOR PLANTING AT LOWER LEVELS.
(Page 42.)

barrage were only adopted, the project would be carried through in some way or other, as the only question then would be merely a choice of methods and material; and the bureau had no doubt that the material question could be solved in a satisfactory manner. It may be added that the measures above referred to bore fruit, since the project was adopted by the Navy Department without much loss of time after the Bureau of Ordnance reported that a suitable mine had been developed. Furthermore, the President's attitude was known in advance to be favorable; and the project, when adopted by the department, was promptly approved by him.

One of the earliest and most enthusiastic proponents of the northern barrage project was Assistant Secretary of the Navy Franklin D. Roosevelt, to whom was given a copy of the memorandum of April 15, 1917, and with whom the matter was discussed in a general way. The Assistant Secretary's keen interest in the matter was very apparent throughout the early phases of the project; and it is understood that he took up with the Bureau of Yards and Docks the problem of a net barrage across the North Sea. While the details of this study are not known, it is assumed that effort along that line was stopped when it became known that the Bureau of Ordnance had a suitable type of mine, which, of course, was readily accepted as far preferable to any net plan.

In the month of May, 1917, the Department of Commerce became interested in a barrage proposed by certain officers of the Coast and Geodetic Survey; and the Secretary of Commerce took up the matter with the Navy Department and strongly urged that the two departments collaborate in designing and putting down such a barrage. It is needless to go into details regarding its design, and the mere statement will suffice that it was to be composed of nets in combination with mines, and that the net was composed in part of insulated wire, the breaking of which wire by a submarine would fire a mine. There were several conferences, one of them presided over by the Secretary of Commerce and attended by Assistant Secretary Roosevelt, Commander Fullinwider, and Lieut. Commander Castle. The Bureau of Ordnance was not favorably disposed toward this plan, because it felt that, even if the necessary quantity of material could be obtained, which was doubtful, it would be a very difficult project to carry into execution, and furthermore, that it would be quite impossible to maintain it in waters such as the North Sea. Plans were adopted to carry out tests in deep water, but interest in this plan ceased when Mr. Roosevelt became convinced that the Bureau of Ordnance had developed a satisfactory mine for a barrage.

The foregoing is mentioned only to show the active and growing interest at that time in the idea of a barrage. It also became a favorite problem with inventors. In short, by the time the bureau

had demonstrated to its satisfaction that the new mine would be effective, the closing of the North Sea was quite recognized in America as the best possible solution of the anti-submarine problem. It remained to convert the British naval authorities to this view.

The adoption of any plan for a barrage to close the North Sea was, of course, dependent upon the suitability and availability of the material, and so the development of the project was largely the development of the Mark VI mine. It should be stated in this connection, however, that the northern barrage would undoubtedly have been realized whether or not the Mark VI mine had been adopted for the purpose. There were other designs of mine available but the Mark VI was deemed the most promising in sight at that time.

In April, 1917, Mr. Ralph C. Browne, a citizen of Salem, Mass., an inventor associated with the L. E. Knott Apparatus Co., Cambridge, Mass., brought to the department a description of an invention which he called the "Browne submerged gun." Assistant Secretary Roosevelt referred him to the Bureau of Ordnance, and the invention was duly considered by the Chief of Bureau and Commander Fullinwider and Lieut. Commander T. S. Wilkinson. The invention in the form offered may be briefly described as follows: A buoy or float carried as an integral part, a so-called gun or short tube extending vertically downward. The buoy carried also a copper wire hanging vertically. A high-explosive shell was carried in the tube or gun. This shell contained in its base a propelling charge of slow-burning powder intended to give the projectile a velocity of about 50 feet per second through the water. The shell was provided with guides to restrict it to travel along the wire. The float carried also an electrical relay mechanism, all parts so related that the contact of a submarine or any steel vessel with the pendent wire would produce a sea-battery current of sufficient energy to actuate the electric relay, which in turn would ignite the propulsive charge in the base of the shell and send the shell along the wire into contact with the submarine, where the shell was expected to burst and rupture the hull. The design was very ingenious and novel as a whole; but in its then proposed form it was deemed by the Bureau to be wholly impracticable for naval use. Commander Fullinwider saw, however, that the electric principle involved might be applied to a mine firing device; and, after making a study of the matter with Capt. S. J. Brown (Math.), United States Navy, and Lieut. Commander Wilkinson, and after reference of such study to the Chief of Bureau, he suggested to Mr. Browne that he collaborate with the Bureau in applying the new principle to an antenna mine. This Mr. Browne was loath to do as he felt that his invention would be more effective than would a mine. After about two weeks' investigation, including considerable pressure by the Chief of Bureau himself, how-

ever, Mr. Browne agreed that he would defer to the bureau's judgment in the matter and consented to collaborate with the Bureau in the development of a mine-firing device based on the use of a sea battery.

Mr. Browne immediately took up the work, and on June 18, 1917, a crude model of a mine-firing device was tested with promising results at the submarine base, New London, Conn. Further tests were held on July 10; these tests were conducted by the experimental officer of the Bureau. It was immediately subsequent to these tests that it was finally decided to adopt the new firing device, and the Bureau proceeded to design and develop a mine in which this device could be used.

The Bureau was convinced by the tests that the device, which was thereafter to be called the K–1 device, was correct in principle, but realized that in the short time available for development and experimentation it could hardly be hoped to obtain reliability in the mechanical features of the design. However, since it was essential that mines for the barrage should be ready in large quantities by the following spring, it was decided to proceed with the manufacture of the devices and trust to making any necessary modifications after getting into production, and in the meantime to proceed with tests, so far as tests could be conducted without complete mines.

It may be stated here that, although the design of the complete mine had not yet been decided upon, and could not be completed for several months, the mine section of the Bureau of Ordnance was sufficiently assured of the successful development of the mine to submit tentative plans to the Chief of Bureau; and he took the responsibility of formally committing the bureau to this method of closing the North Sea.

On July 18, 1917, the bureau addressed the following letter to the Chief of Naval Operations announcing the development of a new type of mine firing gear which would be suitable for mines for a northern barrage:

Confidential.

JULY 18, 1917.

To: Chief of Naval Operations.
Subject: Submarine mine barriers, material for.

1. The Bureau has developed a new type of mine, at present referred to as Mark VI (Type X) which it is confidently believed will facilitate the establishment of submarine barriers. The mine is radically different from other mines in its firing gear, which has been tested out with excellent results and the bureau is now proceeding with the design of the mine as a whole and expects to complete it within two weeks.

2. The new mine will be as easily planted as the ordinary types of naval defense mines and therefore the time and the number of vessels required to establish a barrier will be reduced to a minimum. This mine can be rigged so as to be safe as regards surface vessels, but effective against craft operating below the surface.

3. The mine will be comparatively simple in design and it is believed that it can be manufactured at a minimum rate of 1,000 per day, which means that the number required for about 300 miles of barrier can be produced within about three months from the beginning of deliveries or within four months from the placing of orders.

4. The Bureau requests that a decision be reached at the earliest practicable moment as to the desirability of establishing complete barriers to prevent enemy submarines from gaining access to the Atlantic. The Bureau assumes that such a project is desirable as no other means of stopping the submarine peril appears to be in prospect, and, since it is going to take four months to obtain the necessary material, the Bureau believes that it should be authorized to proceed immediately with arrangements for procuring the material.

5. Theoretically, only 72,000 mines will be required for 300 miles of barrier, but 100,000 should be provided to allow a reasonable excess for replacements, etc. In addition, a number, say 25,000, should be provided for our own coast defenses, it is believed, making a total of 125,000 mines, which, at an estimated cost of $320 each, gives a total cost of $40,000,000. This estimate is designedly liberal.

6. The Bureau is of the opinion that the design, manufacture, and assembly of the new mine should be carried out with the utmost secrecy and is taking the necessary precautions accordingly, since advance information of such a mine would be of the greatest aid to the enemy in devising means to counteract it.

7. The above estimate as to time is based upon our success in securing the necessary quantity of T. N. T. or other high explosive.

8. In considering this project the use of high-speed mine-laying vessels, such as liners and merchantmen, in addition to destroyers and light cruisers, will be required and such vessels must be provided. The mines can be dropped accurately at any speed by time devices. The whole barrier should be laid as one operation and be protected as far as possible. If isolated mines are planted, it is probable that a device to defeat the mine-firing mechanism will be developed by Germany.

RALPH EARLE.

While awaiting the Department's action, the Bureau proceeded with the design of the mine, with a view to being prepared at the earliest possible date to undertake its manufacture.

On July 30, 1917, the Bureau addressed a second communication to the Chief of Naval Operations, submitting more complete information regarding the new mine and proposing an American-British joint offensive operation in the form of a northern barrage. A copy of this letter follows:

(N3) MC. JULY 30, 1917.

To: Chief of Naval Operations.

Subject: Proposed British-American joint offensive operations; submarine barriers; Mark VI mines.

1. In its letter No. 32957 of July 18, 1917, the bureau announced the development of a new type of mine that is peculiarly adaptable for use against submarines.

2. The firing mechanism of this mine is based on a very recent discovery in the electrical field, and although there has been little time for development the tests which have been carried out with an experimental mine by a submarine leaves no doubt in the bureau's opinion of the success of this invention.

3. The mine will have the following characteristics:

(*a*) A spherical mine case carrying a charge of 300 pounds of T. N. T. having a destructive radius of about 100 feet against a submarine.

(*b*) The anchor may be either the automatic type, such as that now in use or a simple mushroom type, depending upon the conditions under which mining operations shall be carried out.

(*c*) The firing mechanism comprises an electrical device carried within the mine case and an antenna of any desired length, the end of which will be supported by a small buoy as near the surface of the water as may be desired. A second antenna may be suspended from the mine where the depth of water renders this necessary.

(*d*) A steel vessel coming in contact with the antenna will fire the mine.

4. The mine has the following advantages over other types:

(*a*) In depths of less than 100 feet it may be planted on the bottom, where it is least affected by wave action and current. In this case a buoyant mine is not necessary or desirable, and it can be made smaller and cheaper than a buoyant mine. In such circumstances there is no possibility of its getting adrift, and it can not be swept up in the usual way. It can, however, be fired by a mine sweep.

(*b*) In depths greater than 100 feet it is proposed to submerge the mine to a depth of 100 feet, since 100 feet is about its destructive range against submarines. At this depth the mine itself is entirely protected from wave action and only the light float or buoy is exposed to such action.

(*c*) Where conditions permit the antenna may take the form of a net, or the antennæ of adjacent mines may be connected by horizontal wires forming an impassible barrier.

(*d*) If a floating mine be desired, this mine may be suspended from a buoy in such manner as to be harmless to surface craft but deadly to submarines submerged.

(*e*) It may be used as a towing mine with antennæ to give it a very large danger space.

(*f*) It can almost entirely replace submarine nets of present types.

(*g*) It can be used for mining very deep water more easily than can other types.

5. The mine, with its anchor, antenna, and buoy, will be assembled and launched as a unit, so that it can be launched at high speed from destroyers if desired.

6. The bureau believes that with this mine it becomes practicable to close the North Sea, Adriatic, and other exits of enemy submarines, and that it gives us our opportunity to cooperate in carrying into execution a major offensive operation of a decisive character. Even if the proposed barriers should prove to be only 50 per cent effective, the enemy's submarine campaign would surely fail.

7. It is suggested that the North Sea barriers must extend from the coast of Scotland to Norway and across the English Channel. The proposed line from Scotland to Norway must, to be at all effective, extend into the territorial waters of Norway, thereby involving the question of Norway's neutrality. It would seem that if the German submarine is permitted by Norway to use her territorial waters, it becomes incumbent upon the Allies to take measures to prevent such use.

8. The proposed mine barrier scheme does not infringe upon the neutrality of Holland, Denmark, and Sweden, except in the restricted sense that the vessels of those powers, as well as of Norway, would be required to pass through a gate in the barriers under the control of the allied forces. In effect, this would amount to the establishment of additional danger zones to be avoided by neutrals.

9. The bureau understands that the British Admiralty has objected to any barrier in the North Sea that would interfere with the freedom of the British fleet. It is suggested that a gate should be left in the barrier at an appropriate place near the Scotch coast, not only for British naval vessels, but also for neutral merchant vessels. This gate would be, say, 8 miles long, with mines so planted that their antennae would not come within 40 feet of the surface at low water. In other words, the subsurface would be mined against submarines and the surface left open. This gate could be effectively patroled with a very few vessels and submarines attempting to pass on the surface could be destroyed.

10. If a decision should be reached immediately to proceed with the assembling of the material for these barriers, it would require approximately six weeks to complete the designs, place the orders and start production on a large scale. After starting production mines could be obtained at a minimum rate of 5,000 a week, and if the project were given the importance due it there is no doubt that the manufacturers could be depended upon to increase this figure. In this connection it is assumed that the British Admiralty would be willing to cooperate to the extent of furnishing a portion, at least, of the mine anchors, but it is believed that we should supply all of the mines with the exception of the anchors.

11. It would require approximately 72,000 mines to establish barriers around the North Sea, assuming that the barriers will be composed of four lines of mines, placed 100 feet apart in each line, in other words, a barrier would require a mine for every 25 feet. To this 72,000 should be added at least 28,000 for renewals and as a reserve. If it should be decided to place the barrier across the Adriatic and to close the Dardanelles about 50 miles of barrier, or about 15,000 additional mines would be required.

12. It is estimated that 125,000 mines can be manufactured at a cost of $40,000,000.

13. The bureau has made every effort to keep the discovery and development of this mine a military secret, and it is believed that this secrecy can be maintained by proper organization and administration until such time as it becomes necessary to assemble the completed mines to ship them to Europe. To this end, the various parts of the mine will be manufactured by different companies and no manufacturer need be informed as to the characteristics of the mine as a whole. The company which will manufacture the firing gear has taken such precautions that only three members of the company will know that the electrical apparatus used in the mine is intended for a mine.

14. In view of the importance of keeping this matter a military secret, it is considered desirable that the British Admiralty should not be informed as to the features of the mine until the mines shall have been manufactured and shipped. This view is taken because it is inevitable that information will leak out regarding the design, if any considerable number of persons should become informed of it, and since it is proposed to manufacture the mines complete in this country, it would seem unnecessary to send any information regarding it abroad and would only invite the possibility of such a leak.

15. If the enemy should learn of this invention it would be easy for him to evolve a similar mine which he could use to blockade the British ports. The principle of the firing mechanism is so simple that only the slightest clue would enable the enemy to duplicate it.

16. If this project should be carried out, the bureau is of the opinion that its execution will bring about a general engagement with the German Fleet, which it is supposed is desirable.

17. The following is a summary of the cooperation deemed necessary to carry out this plan:

United States:

(*a*) Provide mines, except anchors.
(*b*) Send mines to England.
(*c*) Assist in assembling mines in England.
(*d*) Provide a number of minelayers.
(*e*) Assist in laying.

Great Britain:

(*a*) Provide anchors.
(*b*) Assemble mines on anchors.
(*c*) Organize and equip minelaying force.
(*d*) Lay all mines with United States assistance.

18. In the above it is suggested that Great Britain provide the anchors, for the reason that about 30,000 tons would be required and that the transportation of this tonnage should be avoided if possible.

19. Regarding the minelaying part of this project, it is understood that Great Britain has about 18 regular mine layers and that the United States could probably furnish 4, giving a total of 22, not including destroyers. A number of British destroyers are fitted to carry 80 mines, and probably some of ours could readily be fitted to carry 40 to 80 each, so it is assumed that 40 destroyers may be available. The minelaying program may then be assumed to be approximately as follows:

(*a*) Twenty-two minelayers could lay 200 mines per day each. If they take one day to reload, they would lay an average of 100 per day each.

(*b*) Forty destroyers could average 50 per day each.

(*c*) All combined could lay 4,200 per day.

(*d*) For the Northern barrier about 60,000 mines are required. These, at the rate of 4,200 per day, could be laid in about 15 days.

(*e*) For the English Channel barriers, assumed lengths 50 miles, 12,000 mines would be required. At the rate of 4,200 per day these could be laid in three days. It is assumed that two barriers each 25 miles long would be required in the channel to fully protect the Channel crossing.

20. Lacking definite information as to the minelaying facilities in the Mediterranean, but, assuming that 10 vessels could be made available, the Adriatic barrier, 40 miles, could be laid in about one week and the Dardanelles barrier in a shorter time.

21. As the manufacture and assembling of the material will be an immense undertaking, and as time is precious at this juncture in the war, a decision should be reached at the earliest moment practicable.

22. If this plan be adopted, it will be necessary to expedite manufacture by giving this work priority over certain other Government work, particularly in the matter of obtaining a sufficient supply of T. N. T. This will be made the subject of special report if the general plan be adopted.

KEARNEY, *Acting.*

On August 15, 1917, Admiral Mayo, Commander in Chief, Atlantic Fleet, who was about to proceed to England accompanied by certain members of his staff, conferred with the Chief of Bureau and officers of the mine section regarding the new mine and its value for the proposed Northern Barrage. This discussion covered not only the material questions but also matters of strategy and tactics involved in such an undertaking. The Bureau furnished Admiral Mayo for his information and for use in discussing the matter with the British naval authorities a memorandum embodying the ideas of the Bureau of Ordnance concerning the adaptability of the Mark VI mine for a barrage. This memorandum is quoted below for the reason that it set forth with fair accuracy the possibilities and limitations involved in the use of the new mine and, in connection with the above-quoted letters to the Chief of Naval Operations, supplied the information necessary for an intelligent consideration of the Northern Barrage project.

(D3)MC Confidential.

AUGUST 15, 1917.

MEMORANDUM FOR COMMANDER IN CHIEF, ATLANTIC FLEET.

Subject: Mark VI mine.

Inclosure: (A) Copy of Bu. Ord. letter to Chief of Naval Operations, dated July 30, 1917.

1. The following notes are intended to amplify and supplement the information contained in the inclosed letter:

2. From the early stages of submarine warfare trap nets have been used to a considerable extent, but it has been found to be extremely difficult to maintain nets of sufficient weight and strength to stop submarines, and it has lately become known that submarines are equipped with cutters which enable them to cut their way through. Inasmuch as the submarine is free to go to a depth of 200 feet, a heavy trap net in deep water necessarily becomes a serious problem, not only to manufacture and plant but also to maintain against the wear and tear due to storms and currents, etc. The Bureau early became convinced that a trap net designed to offer passive resistance to submarines is not a sure solution to the problem.

3. Indicator nets of various designs have been studied and much information regarding foreign types of such nets have been fully considered with the conclusion that this type of net also is not a satisfactory anti-submarine device. Such nets must be suspended from surface floats and cables are subjected to extreme conditions of wear and have a short life. But the principal objection to such a net, when it is not combined with bombs or mines, is that it merely indicates the presence of a submarine and that it requires a very large number of patrol vessels to keep a close watch on the net in order that a vessel may be near at hand to destroy a submarine whose presence is indicated. With a view to reducing the number of attendant vessels, a radio buoy has been developed to send out a call automatically in the event of a submarine fouling an indicator net, but the defect of this scheme is principally that a submarine has an excellent chance to get clear of such a net by the time a patrol vessel could arrive on the scene.

4. Nets in combination with mines or bombs are better, on paper at least, than either the trap nets or the indicator nets; but here again the difficulty of planting and maintaining such nets on a large scale, for example, the proposed North Sea barrier, would be prohibitive. The Bureau has examined and carefully considered hundreds of inventions and suggestions relative to nets of all descriptions, and has come to the conclusion that the only effective barrier that could be manufactured, planted, and maintained effectively is one of mines.

5. The German, British, and all other types of mines known to this bureau are unsuitable for the formation of barriers in deep water, mainly because of the great number of mines that would be required for any major operation, such as the North Sea barrier. Since submarines can go with safety to a depth of 200 feet and since the ordinary mine must be actually struck to be effective, one of the first ideas that occurred to the bureau was that pendant mines might be used; that is to say, a number of small mines at intervals of, say, 25 feet, on a vertical pendant 200 feet long, but this was not seriously entertained because it is obviously clumsy and such mines would necessarily have to be supported from the surface by an elaborate system of buoys, cables, and moorings, and such a system would be difficult to fabricate, plant, and maintain.

6. It early became evident that what was needed was a mine that would give a very much larger danger area than any mine in existence, and fortunately the new firing principle embodied in the Mark VI mine was hit upon and proved on test to be entirely practicable.

7. By giving the mine a sufficiently heavy charge of high explosive, to disable a submarine at a distance of 100 feet, and by making the mine effective by mere contact of a submarine with its antenna 100 feet above and below it, it is apparent that a great advance has been made possible in antisubmarine mining operations.

8. The mine will be charged with 300 pounds of high explosive, probably T. N. T. or a combination thereof with some other substance. The British publications on the subject of depth charges allot a danger radius of 70 feet to a charge of 300 pounds of amatol (60 per cent T. N. A. and 40 per cent ammonium nitrate). From French information and from experimental data in possession of the bureau, it is concluded that the positive destruction area of such a charge is within a radius of 70 feet, but that within a greater area of a 100-foot radius sufficient damage may be expected to force the submarine to come to the surface. Accordingly it is considered that the use of these mines with an antenna 100 feet above the mine and another 100 feet below the mine will permit the explosion of the mine upon the passage across its vertical plane in contact with the wires of any submarine within 100 feet above or below the mine. It will readily be seen that this increases the effective "contact area" in the ratio of the 200 feet length of the antenna to the 3 feet diameter of the present contact mine in use by the Allies. In other words, one mine will cover all practicable depths for a submarine, as it is not probable that submarines will cruise below 200 feet depth. The "contact area" of the mine may be still further enlarged by transverse antennæ connected to adjacent mines forming a network, but owing to the difficulties of laying such a barrier in the open sea, it is considered preferable to lay several parallel rows of unconnected mines.

9. Anchors will be of three different types, viz:

(*a*) Automatic anchor, similar to present British type, for use where automatic depth regulation is desired.

(*b*) Nonautomatic anchor for use in depth of less than 100 feet; fixed length of anchor cable to hold mine close to bottom where effects of wave action and current will be minimized.

(*c*) Modification of (*b*) nonautomatic anchor for depths exceeding 100 feet, but where depths are fairly uniform. Length of anchor cable to be set for predetermined depth to give mine submergence of 100 feet.

10. The third type of anchor (*c*) is desirable only to save time of manufacture, it being simpler than an automatic mine, but it would require more time and care to plant owing to the necessity of knowing the depth fairly accurately. Its principal use would be in home or controlled waters.

11. In view of the fact that the mine will be at a depth of 100 feet or on the bottom (in depths less than 100 feet) it will be affected by wave action and the effect of current will be less than with the usual type of mine, therefore the mine anchor can be lighter than that of other mines. It is proposed, however, to back the anchor with a small light anchor (in combination with the plummet or otherwise) to insure holding.

12. All anchors of whatever type will, of course, fit the standard mine track, and all mines, regardless of type of anchor, will be launched in the same manner.

13. The scheme of mine laying contemplates separating the mines in each line by a distance of 100 feet, and laying four separate lines, mutually distant 500 yards and whatever distance is found necessary for safety and convenience in laying. In this manner a barrier of practically one mine per 25 feet (since in all probability the several lines will be staggered with respect to each other) will be created. It is estimated that it would be well-nigh impossible for a submarine to pass through the four lines without striking a mine in some one of the lines. This distance apart of 100 feet insures freedom of the mines from countermining each other.

14. If the upper antenna is made of such length that it reaches the surface, the passage of surface craft coming in contact with the antenna will fire the mine. This

may be prevented in cases where it is desired to leave "gates" open for the passage of the fleet by submerging an antenna to a depth of 50 feet. This will probably suffice to strike all submarines operating entirely submerged, because it is understood that they cruise usually at a depth of 60 feet in order to avoid fouling the bottom of surface craft which they can not see. The surface of these gates must, of course, be thoroughly patrolled in order to prevent the passage of submarines on the surface, or submerged but with periscope showing. In case, however, of explosion of one of the mines by a surface vessel, serious damage would unquestionably result to a merchant vessel. War vessels, however, by reason of their superior strength and interior subdivision, would be able to stand with comparatively little damage, the explosion of the mine at a distance.

15. For a barrier to be completely effective against submarines, the entire depth of water from the surface to 200 feet should be mined; in other words, the buoy of this mine should reach almost to the surface in order that a submarine on the surface might be destroyed or seriously damaged. With a barrier of this kind, great care would be necessary to keep friendly vessels away from the danger zone, and to this end it would be necessary to put down navigational marks, either vessels or buoys, to mark the danger zone and to facilitate the work of additional mine planting when such becomes necessary.

16. The use of a steel sweep metallically connected to the sweeping vessel with a steel underbody would explode the mines. This presents two advantages:

(*a*) In case of sweeping by the enemy no mine can be picked up and the construction thereof examined.

(*b*) After the war the mines may be readily removed by exploding them. If the recovery of the mines for stowage and use is desired, however, this can readily be done by using a parcelled sweep and insuring that the sweep is connected to the sweeping vessel by means of some nonmetallic joint.

(*c*) The proposed plan of laying these mines contemplates their use in waters where enemy sweeping operations could not be carried out without driving off the patrol.

17. The mine is protected from premature firing by two breaks in the electric circuit. The first of these is closed by the hydrostatic pressure of the water after the mine is launched. The second is not closed until the contact of the submarine or other steel vessel with the antenna. The second break is further protected by a mechanical lock not liberated until hydrostatic pressure is applied on the mine on submergence, and by an electrical ground which is not connected until the mine is in the water and the buoy and antenna have paid out. The rugged character of this safety device and its efficiency have been amply demonstrated by tests. Still another safety device is an "extender" which forces the primer into firing position relative to the detonator only after submergence of the mine to a predetermined depth.

18. The firing element of the mine is a dry-cell battery completely sealed up. It is estimated that the life of this battery as thus sealed is at least two years, with probably much longer life.

19. There are no insulated electrical parts outside the mine case. All electric circuits within the case are carefully insulated, and in addition they carry such feeble currents that there is no difficulty to be anticipated from short circuits, grounds, or defective insulation. The lower antennae wire must be metallically insulated from contact with the bare metal of the mine case or the mine cable. This can be accomplished by coating the mine with a nonmetallic bitumastic compound and by parcelling the anchor or mooring cable. Electrical insulation is not necessary, simply mechanical insulation to prevent actual contact of the two bare metals.

20. The action of pronounced currents especially where the mine is laid in very deep water, would be to deflect the mine from the vertical and consequently, since

its mooring rope is of fixed length, to increase the submergence of the mine to some degree. This difficulty may be overcome by floating spare lengths of antennae on the surface, so that when by current action the mine is submerged, the spare length then becomes an additional antenna buoy, now somewhat submerged. The tilting action on the mine will not prevent the operation of its mechanism. In addition, the deep submergence of the mine will remove it to a large extent, from influence by surface currents and wave action, and will subject it only to legitimate deep currents which do not, in the water in which it is proposed to lay these mines, reach any high value.

STRATEGICAL AND TACTICAL CONSIDERATIONS.

21. In order to present a fair chance of success, these mines must not be laid as surprise mines in waters wherein the enemy has control, but must be located at a distance from enemy bases sufficient to insure absolute control of the waters by the allied forces. This would then insure the maintenance of an adequate and continuous patrol and the prevention of sweeping operations.

22. In planning for the material required for the North Sea barrier, the line from Buchan Ness, on the east coast of Scotland, to the coast of Norway was assumed as a possible line. This line is an extreme example of a barrier because of its length and the depth of water traversed, though its currents are favorable.

23. It is evident that such a barrier would restrict freedom of action of the British fleet based on the coast of Scotland, inasmuch as it would not be free to cross the barrier line at any point except where a "gate" had been established. This gate could be any width desired, say, 15 or 20 miles, and there could be more than one gate.

24. Assuming that the North Sea were inclosed by effective barriers, and assuming that the enemy had 200 submarines in the North Sea and confined thereto, it is to be expected that the enemy would attempt to trap the allied forces. For example, suppose that a gate 20 miles wide were left in the barrier, near the coast of Scotland, and that this was the only means by which the allied fleet could pass in and out of the North Sea. It is to be expected that the enemy might dispose his submarines in appropriate positions in the neighborhood of such gate, that he would then send his main fleet into the North Sea to make a demonstration and try to draw the British and allied forces into an ambush. The important question arises, therefore, as to whether the British and allied fleets could reasonably expect to cope with such a situation. It seems reasonable to expect that by means of patrols and sweepers a large area of sea adjacent to the proposed gate could be kept under control and made fairly safe for the fleet. However, denial to the German submarines of access to the Atlantic would intensify submarine activities in the North Sea. The enemy would also be likely to attempt to raid and sweep or destroy parts of the barrier. This would necessitate constant and vigilant patrol by fast, light cruisers and destroyers, and it is to be expected that this condition would bring on heavy engagements with the enemy if not a main-fleet action.

27. Further tests are about to be made of a number of mines to demonstrate their reliability under varying conditions of service, and their safety in handling, but as the firing gear is the only really novel feature of the mines, and as that has stood every test yet applied to it, there appears to be no possibility of failure.

28. The manufacture of 10,000 mines for our own service has been started. This initial lot of 10,000 will prepare manufacturers concerned for production of larger quantities.

T. A. KEARNEY, *Acting.*

As will be subsequently seen, the tentative design of the mine had to be modified as a result of experiments and more mature study of the project. Notably, the use of a lower antenna was decided to be impracticable or inadvisable; and the spacing of mines had to be increased to 300 feet to reduce the danger of countermining. It was found, too, that the Bureau of Ordnance had been too optimistic in its forecasts relative to early completion of design and early production, due principally to the lack of sufficient experienced personnel in the early stages of the project.

The foregoing carries the history of the northern barrage to the point of its formal submission to the British Admiralty by the Navy Department through Admiral Mayo.

Chapter II.

BRITISH CONSIDERATION OF PROJECT.

A British Admiralty "History of Northern Barrage" states that—

Toward the end of August, 1917, Commander (Acting Capt.) Alan M. Yeats-Brown, D. S. O., R. N., after having made various proposals during the preceding two months with regard to anti-submarine measures, produced a paper entitled "Anti-submarine Mining Proposals." This paper was referred to the plans division. This division had already been considering these matters for some time, and, after consulting with Capt. Yeats-Brown on several points which he had brought forward, suggested certain modifications to the proposals and wrote an appreciation on Capt. Yeats-Brown's paper. The conclusions arrived at were brought up for discussion at the next allied naval conference by the First Sea Lord, who, it is believed, had previously discussed the matter with Admiral Mayo, of United States Navy.

The northern barrage project was taken up at an allied naval conference at London, September 4–5, 1917, attended by Admiral H. T. Mayo, United States Navy, where, as reported by him on September 8: "The British Admiralty put forward, as an alternative to a close offensive in German waters, the suggestion that the activity of enemy submarines might be restricted by the laying of an effective mine-field or mine-net barrage." The mine-net barrage was considered impracticable and "as to the proposal to put down a mine barrage in the northern part of the North Sea, while it could be guarded against enemy sweepers, certain difficulties exist such as lack of freedom of movement of the Grand Fleet, so that a very promising degree of success should be indicated before such an undertaking was begun." Further, "the conference, after discussion, agreed that the distant mine barrage could not very well be undertaken until an adequate supply of mines of satisfactory type was assured."

The British Admiralty history, in reference to the proceedings at this conference, states:

Admiral Jellicoe put forward the suggestion of laying "an efficient barrage so as to completely shut in the North Sea."

He computed that 100,000 mines would be required. He remarked (*a*) "I do not think we get many German submarines by mines"; (*b*) "It appears that the result of our mine fields (in the Bight) is to force the submarines, or a very large proportion, to go in and out of the German bases through territorial waters or Dutch territorial waters"; (*c*) "There is the alternative of laying a mine field in the North Sea in a position where the enemy sweepers can not reach without running very considerable risk. In view of our present experience I do not think that would have much more result than our present policy; but if a mine is produced which is more effective against submarines than our own mines the matter perhaps becomes somewhat different. * * * We get our mines slowly. Our problem is then: Is it better to put them down as we get them or is it better to wait until we get a very large number

and lay a complete barrage across the North Sea? * * * It is obvious a mine field so laid would have to be at some considerable distance from German ports, because it would require to be watched. * * * A great deal depends upon whether the mine is a satisfactory one. If we get a satisfactory mine, it might be worth while laying a barrage when we get a sufficient number."

Admiral Mayo approved the idea of a mine barrage involving patrol by the allied fleet, provided always that we had confidence in the efficiency of the mine which would be laid. He thought that this promised really more in the way of results than the proposed operations in regard to the convoy of ships.

Vice Admiral Sims said, "It must be successful completely or it is not successful at all. Either the barrage is successful absolutely or it fails absolutely."

Sir Eric Geddes said, "I do not understand from the remarks of the First Sea Lord that the barrage should take the place of other offensive measures. It is not considered that the barrage can be sufficiently relied upon to take the place entirely of other measures for hunting and destroying submarines."

As for Sir Eric Geddes's statement, he was in exact accord with the American proponents of the project, who, from the first advocated it in addition to other useful antisubmarine measures.

The results of the conference may be summed up as indicating a favorable attitude in principle toward the northern barrage project leavened with doubt of its practicability. The reasons for this doubt are surmised to have been the generally unfortunate experience of the British in the development and use of mines. At the outbreak of war in 1914 the British had practically no mines, and, for want of a better one, adopted the Vickers-Elia type, which soon proved unreliable and ineffective. This was superseded by one of British Admiralty design, essentially similar to the Russian and German horn mines, but with a distinctly British sinker (anchor). This British horn mine, while perhaps an improvement on the Vickers-Elia, was not entirely satisfactory, being comparatively dangerous to handle, too susceptible to countermining, unreliable in automatic depth taking, and not of a type lending itself to rapid and economical manufacture.

For some reason, perhaps their own rather slow and unsatisfactory progress in the development of mines, British officials apparently were skeptical of the ability of the United States to produce quickly a more satisfactory type. This attitude first became apparent to the Bureau of Ordnance on June 2, 1917, when Admiral Sims, in a dispatch to the department, reported: * * * "the British Admiralty have concentrated upon the construction of mines to such extent that they now anticipate that by August the output will reach 10,000 a month. They consider it unwise from their previous experience with mines similar to those which we now have on hand to attempt to utilize our present available supply. They now consider * * * as our output of a different type mine would not be available in sufficient time, that we can more profitably concentrate on other work."

An immediate result of the conference was the production on September 14, 1917, by the Admiralty plans division of a paper for

Admiral Mayo entitled "General Future Policy, Including Future Mining Policy" with an appendix, "Mine Barrage Across the North Sea." The following extracts from this paper bearing on the barrage project are quoted:

The enemy submarine campaign now dominates and overshadows every other consideration, and any increase in the present rate of sinking might bring about an unsatisfactory peace.

* * * it therefore appears that our future policy must be directed toward a more concentrated and effective control in the areas between the enemy's ports and our trade routes.

Some form of barrage corresponding to that which was formerly established by the battle fleet * * * must be reconstituted in such a form that the enemy submarines can not venture into it without considerable risk to themselves.

Broadly speaking, four forms of barrage may be considered—

Firstly. A barrage of mines only * * *.

Secondly. A combination of deep mines with surface and aircraft.

Thirdly. Surface and aircraft patrolling a wide belt.

Fourthly. Sealing the submarine exits * * *.

The fourth form of barrage * * * is the only radical cure * * * but the difficulties * * * are so great that it is not recommended to attempt it.

It is therefore proposed to use a combination of the first three.

* * * The enemy submarine would thus be subject when on the surface to attack of one kind or another from shortly after leaving their bases until they cleared the Orkney-Shetland-Norway line, in addition to passing through a mine barrage * * *.

The paper also dealt with the protection of the barrage, remarking "* * * with our fleet based on Rosyth we should be in a position to insure protection even to the area between the notified area and the Norwegian coast."

The use of neutral waters by enemy submarines was also dealt with. "* * * this can only be overcome by converting the neutral into an ally or by ourselves preventing the enemy submarines from using these waters * * *. Should Norway come in on our side, Stavanger * * * could be used as a base for a fleet or for the light watching forces, as desired. Should, however, the general situation render it undesirable to include Norway among the Allies, any development of the selective-type mine would enable us to deal with the passage * * *."

The appendix dealt with the details of the mine barrage which it was proposed to establish on the Aberdeen-Ekersund line, and was at that time of such importance to the further consideration of the project, particularly to the Navy Department, that it is quoted in full below:

APPENDIX I.

MINE BARRAGE ACROSS THE NORTH SEA.

The object of mining the North Sea is to prevent the enemy submarines from getting out, but it is most undesirable that any mine barrage should hinder the movements of our own fleet or lay our coasts open to attack, if it can be avoided.

Before considering the line to be selected, the requirements of an effective mine barrage will be considered.

The requirements are as follows:

(1) The mine field must be guarded; that is to say, it must either be—

(*a*) At such a distance from the enemy ports that he can not sweep it; or

(*b*) We must watch it and drive off any sweeping vessels he sends out.

Obviously (*a*) is preferable. It is also an advantage to be far enough off the enemy aircraft bases to prevent interference to our patrols by seaplanes or aeroplanes. Zeppelins can be dealt with.

(2) The mine field should be as far from the enemy ports as other considerations will permit to enable our patrols to intercept any submarines damaged but not sunk outright by our mines.

(3) The barrage must consist of both deep mines and mines near the surface; or, if deep mines only are used, the barrage must be patrolled in order to force the submarine to dive to the level of the deep mines.

It is also an advantage if the barrage is in such a position that our main fleet can be based on the enemy side of it, as this will not only give freedom of movement to our own fleet, but in addition should enable us to intercept any enemy vessels which endeavor to interfere with our barrage or the vessels patrolling it.

Consideration of the line to be selected.—The line from Aberdeen to Norway is preferred for the following reasons:

(*a*) Its great distance from the enemy ports, which will render interference from the enemy difficult. Thus, every mine laid in this area will continue to be a menace to the enemy submarines until the end of the war.

(*b*) The line is shorter than any other, with the exception of the Orkney and Shetland-Norway line, which is considered impracticable owing to the depth of water and the strong tides in the Fair Island Channel.

(*c*) The Grand Fleet, if based on Rosyth, is on the enemy side of the line.

(*d*) Any submarines damaged by mines will have a long way to get home and should be accounted for by our patrols.

(*e*) Whether Norway eventually comes in on the side of the Allies or not, the eastern end of the line will be far easier to guard than the northern end of the Goodwin-Jutland line, which has been suggested.

(*f*) It would be easier to bring pressure to bear on Norway to induce them to take steps to prevent submarines passing through their territorial waters than it would in the case of Denmark with their ever-present fear of invasion.

(*g*) The line Aberdeen-Norway deals with submarines using the Baltic exits as well as with those coming from North Sea ports.

Proposed mining policy.—The principles governing our policy to be—

(*a*) Never lay a mine which can be swept in such a position that the enemy can sweep it.

(*b*) Lay mines which can not be swept as close off the entrance to the enemy harbors as possible.

The practical application of this policy to take the following form:

(I) Mine the Straits of Dover with deep mines and patrol the mine field to force the submarines down on to the mines.

(II) Prescribe a mined area on the Aberdeen-Norway line.

(III) Lay deep mines between the notified area and Aberdeen and patrol this line so as to force the submarines down.

IV. Lay deep mines between the prescribed area and Norway when mines become available; in the meantime this area to be watched by hydrophone vessels.

V. Mine close in to the German harbors with destructor mines.

The British Navy to be responsible for mining the Straits of Dover and the entrances to the German rivers.

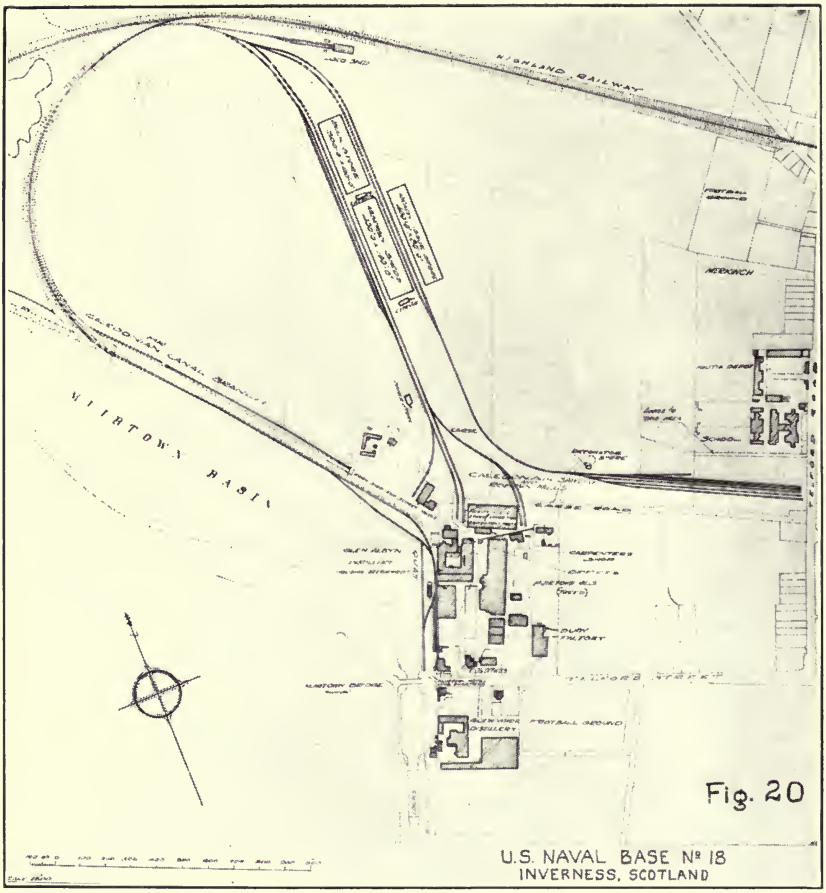
The American and British Navies to cooperate in mining the Aberdeen-Norway route.

It is absolutely essential that the whole of the mines laid in the Aberdeen-Norway barrage should be so constructed that they automatically become safe should they break away from their moorings.

Details of the Aberdeen-Norway mine barrage.—Reference: Chart No. 2182 B.

PHOTOSTATIC CHART. SHOWING LOCATION OF U. S. MINE BASES IN SCOTLAND, BASE 17 AT INVERGORDON AND BASE 18 AT INVERNESS.

(Page 61.)



PHOTOSTATIC CHART SHOWING BASE 18 AT INVERNESS, SCOTLAND.

(Page 65.)

(Page 66.) DUMB LIGHTER LOADED WITH ASSEMBLED MINES AT BASE 18, INVERNESS, SCOTLAND.

(Page 67.) ASSEMBLED MINES IN THE READY ISSUE STORE.

The total length of the barrage may be taken as 280 miles over the greater part of which the depth of water is less than 50 fathoms.

To mine any belt of water effectively there should be three lines of mines at each depth of 5 fathoms (e. g., the vertical distance between lines of mines will be 30 feet).

One line of mines at each depth will be referred to as a "system." Thus the complete barrage will consist of three systems.

It is not considered necessary, however, to lay mines at a greater depth than 200 feet (33 fathoms), as submarines will not willingly go below this depth.

2. The barrage is divided into three parts:

Area A, the notified area. This area has to be made dangerous from the surface to 200 feet below it.

Area B, area C, deep mines with surface vessels and aircraft patrolling.

The above areas will be considered separately.

3. Area A:

It is necessary to make this area impassable to submarines whether diving or on the surface. Three "systems" of mines will be required. If British mines are used, each system will have lines of mines at seven different depths, whereas if American mines are used, each system will only require lines of mines at two different depths.

It is therefore proposed that Americal mines should be used for the area.

The barrage will consist of three systems of lines each, e. g., six lines of mines in all.

Suggested method of laying the mines.—(*a*) The northern edge of area A would be mined first in order to restrict the movements of our fleet to the southward as little as possible.

(*b*) The depth of area A is 56 miles which will allow of the mine field being extended in a southerly direction without a further notification to neutrals.

(*c*) It is of great importance, however, to absorb as little of this space as possible on each occasion of laying mines, and for this purpose three lines of spar buoys will be laid in area A, as shown on chart 2182 B.

(*d*) Only one line of buoys will be required for laying the first and second systems, the third system being laid to the north of the center line of buoys. The presence of three lines of buoys will confuse the enemy as to the actual position of the mines.

(*e*) The spar buoys will be laid at intervals of 10 miles and will be numbered so that the minelayers can ascertain where to commence laying on each occasion.

(*f*) The operation of laying the mines might be carried out as follows:

Two minelayers to proceed to No. 2 buoy and lay lines A. 1, A. 2, as shown on chart. These lines would form part of the first system. The lines A. 1 and A. 2 would be 11 miles in length, the first mine being dropped when 2 miles from No. 2 buoy.

NOTE.—The object in not laying mines until 2 miles away from the buoy is twofold:

(1) It enables the buoys to be approached if it is desired to remove them later on.

(2) The buoys will give no information as to the exact position of the ends of the lines of mines.

On the next occasion the mine layers would proceed well to the eastward of No. 2 buoy, then steer south until they reached the line of buoys, shape course for No. 3 buoy and lay lines A. 1, A. 2.

The second system of mines (lines A. 3, A. 4) would be laid in a similar manner but to the southward of the line of buoys.

NUMBER OF AMERICAN MINES REQUIRED.

It is assumed mines will be laid 40 yards apart.

First system=Length of the line $\times$ number of line $\times$ number of mines to the mile.

$=(11\times11)\times2\times50.$

$=12{,}100.$

Complete barrage, three systems$=3\times12{,}100$

$=36{,}300$

4. *Area B.*—The barrage will consist of three systems. Each system will have a line of mines at each of the five following depths: 65 feet, 95 feet, 125 feet, 155 feet, 185 feet.

It is proposed that the mining of this area should be undertaken by the British. Each system will require 22,500 mines.

Therefore complete barrage =three systems.
=67,500 mines.

5. *Area C.*—It is desirable that American mines should be used for this area as the number of sinkers required is thereby reduced considerably. A decision on this point can only be arrived at when it is known what type of sinker can be used with the American mine.

NUMBERS REQUIRED.

If American mines are used:
Complete barrage=three systems=3×2 lines
=6 lines.
Number of mines in each system=length of line×number of lines×number of mines to the mile.
=60×2×50=6,000.
Complete barrage=three systems=3×6,000=18,000.
If British mines are used:
Complete barrage, three systems=3×5 lines
=15 lines.
Number of mines in each system=60×5×50
=15,000.
Complete barrage=45,000.

NOTE.—This number would be considerably reduced if the X attachment is used.

The copy of the above-quoted Appendix I, which was given to Admiral Mayo for the Navy Department, bore the following notation on its face: "Admiralty would be glad to learn whether Navy Department concurs in the plans as shown."

The Admiralty "History of Northern Barrage" states that "as a result of this paper, it was decided to proceed with preparations for laying a barrage on the Aberdeen-Norway line," and adds that "the date of this decision is not known."

It is important to note that at this period the British Admiralty was apparently quite in accord with the Navy Department in regard to major features of the project, but differed with respect to some of the details. Pending the return of Admiral Mayo to the United States about the middle of October, the development of the project was almost at a standstill for want of information as to British intentions, except in the matter of design and manufacture of the new mines; but the British Admiralty proceeded with the formulation of policies and plans based on the decision to lay the barrage on the Aberdeen-Norway line. These activities will be referred to in detail later.

The location of the proposed barrage, with the proposed area which should be notified (as it was to contain surface mines as well as deep mines), together with the suggested arrangement of the mine systems, is shown in the reproduced chart (fig. 4).

Chapter III.

AMERICAN CONSIDERATION AND ADOPTION OF PROJECT.

Upon the return of Admiral Mayo to the United States a conference was held in the office of the Chief of Naval Operations on October 15, 1917. The following officers were present: Admiral Benson, Admiral Mayo, Rear Admiral Earle, Capt. F. H. Schofield, Capt. R. R. Belknap, Commander Fullinwider, and Commander King.

At this conference Admiral Mayo produced for consideration the above-quoted Appendix I, setting forth the British Admiralty version of the plan for the proposed barrage. There ensued a general examination and discussion of the plan; and, the consensus of opinion being favorable, the Chief of Naval Operations, Admiral Benson, after consultation with the Secretary of the Navy, then and there directed the Chief of Bureau of Ordnance to proceed with the procurement of 100,000 Mark VI mines. This action, so far as the adoption of the project was concerned, was only tentative pending a careful study of the British version; but it was regarded by the Bureau of Ordnance as tantamount to a decision to carry out the project and to provide all necessary material therefor without further delay.

Following the conference, the planning section of the office of Naval Operations and representatives of the Bureau of Ordnance conferred informally as to details of the plan, and the papers in the case were then referred to the general board for consideration.

On October 17, 1917, while the barrage project was under consideration by the general board, the Chief of Naval Staff, British Admiralty, addressed the following dispatch to the Chief of Naval Operations:

> It will be necessary to increase the number of lines of United States mines in each system in the North Sea barrage from two to three if there should be any difficulty in using the lower antennae of United States mines for first supplies. Could you please state an approximate date when supply of complete mines and sinkers will begin, stating at what rate the supply will be maintained?
>
> As all British mine layers will be fully engaged in laying British portions of the barrage will you please say how many United States mine layers will be available * * * and the output of United States mines? It is estimated that each ship could make five mine-laying trips a month. As a base for United States mines and minelayers, it is proposed to use Cromarty. The question of facilities for assembling ready for use, storage, and embarkation is being investigated on the spot. It is suggested that it is desirable that United States officers should confer with ours on this question and examine proposed arrangements as to suitability for dealing with United States mines and sinkers; also to ascertain as to whether our depot system will be suitable

for application to United States mines. It is proposed that the necessary assembling and testing of United States mines and sinkers on receipt and before issue to mine-layers should be dealt with by depot staffs, provided by you if possible. It is hoped that you will be able to agree with this. United States officers if sent over can report numbers required.

I should be much obliged if you would inform me as soon as possible whether you can supply sinkers for United States mines.

On October 20, on the recommendation of the general board, the Navy Department cabled Admiral Sims substantially as follows:

The department requests to be informed whether the plan for the placing of a mine barrage across the North Sea on the Aberdeen–Ekersund line has the approval of the Admiralty. It is believed that the great experience of the British naval forces in North Sea operations and their experience in naval mining during the present war puts them in the best position to decide whether the proposed scheme is practicable in construction and maintenance and whether in the opinion of the Admiralty it is the best scheme in sight for limiting the operations of enemy submarines, provided that the Straits of Dover can be efficiently closed to the passage of submarines, which, if possible, in the opinion of the department, should be done at the earliest possible date.

The following reply in substance was received on October 23 from the Admiralty:

The mine barrier has been approved by Admiralty and the Admiralty now confirms approval. The preparations are rapidly proceeding.

Admiralty's cable of 17th indicates the assistance desired from the United States of America. This scheme is considered by the Admiralty best to be carried out at a distance from the bases of the enemy. The Admiralty are working on a supplemental scheme for operation close inshore, but any such inshore operation has the defect that a passage through for submarines can eventually be cleared by the enemy.

No scheme yet tried has been effective in closing the Dover Straits to submarines, but measures are being constantly improved and they are at the least always a considerable deterrent. Mining operations on an extensive scale against submarines in the Straits of Dover commence in November. Owing to the lack of effective anti-submarine mine, this has hitherto been delayed.

The general board completed its consideration of the project and submitted its report to the Secretary of the Navy on October 24, 1917. A complete copy of this report is appended, but a summary of its "conclusions" is quoted here:

* * * The general board is decidedly of the opinion that of the measures discussed * * * the scheme of closing the North Sea offers the best chances of success—that is, to close the North Sea by the Aberdeen-Ekersund barrier approved by the British Admiralty, and to similarly close the Dover Straits.

The general board does not underestimate the practical difficulties that must be overcome in providing the necessary material and transporting, placing, and maintaining it in the face of the determined efforts of the Germans to render the barrier abortive. Further, the barrier even when placed can not be effective without an adequate patrol. The general board is, however, encouraged to give its indorsement to this plan because it has the approval of the British Admiralty; it is proposed by it as the best practicable plan to meet present war conditions; the Chief of Bureau of Ordnance stated the material, mines, anchors, moorings, etc., can be surely supplied; and the accompanying memorandum of Capt. R. R. Belknap, United States

Navy, who has been actively engaged in conducting mining operations, points the way to handling the details of transporting and planting.

It is assumed that the British Admiralty in approving this plan recognizes the vital importance of the necessary patrol—that it is clearly seen by it where the required number of vessels is to be obtained, and that the extent of the cooperation required of the United States in this regard will be communicated to the United States Navy Department.

If it is decided to proceed with the construction of the Aberdeen-Ekersund barrier, the general board recommends that the preliminaries be arranged at once, and that suitable officers of experience in mining operations be sent to England to arrange for our participation in the work.

The report of the general board was approved by the Secretary of the Navy October 29, 1917, and on the following day the northern barrage project was favorably acted upon by the President at a Cabinet meeting.

On November 1 the Chief of Naval Operations cabled the Admiralty:

Department concurs in project for mine barrier Scotland to Norway and has already taken steps to fit out eight such mine planters to sail February 1. * * * Expect begin shipment of mines January 15. Will send officers to confer and arrange details in a few days.

Chapter IV.

STATUS OF BARRAGE PROJECT ON NOVEMBER 1, 1917.

The American and British authorities having formally adopted the northern barrage project, it is desirable to sum up its major features as understood by the Navy Department, and more particularly by the mine section of the Bureau of Ordnance, whose function it was to procure and provide the mines appropriate to the project.

Referring to the previously quoted Appendix I, which dealt with the details of the proposed barrage, which presumably was the basis of approval by the Admiralty as well as our Navy Department, and which was generally in accordance with the original proposition of the Bureau of Ordnance, the plan embraced the following features:

(*a*) The British Navy to be responsible for mining the Straits of Dover. * * *

(*b*) The American and British Navies to cooperate in mining the Aberdeen-Norway route.

(*c*) On the initiative of the British Admiralty, the northern barrage was divided into three parts:

Area A: The "Notified area." This area to be made dangerous from the surface to 200 feet below it.

Area B; Area C: Deep mines with surface vessels and aircraft patrolling.

(*d*) Area A: Middle area about 160 miles long. To be mined by United States with American mines (antenna type). Barrage to consist of three systems, each system to have a line of mines at each of two depths—100 and 200 feet. Total requirement 36,300 mines.

(*e*) Area B: Western area, about 60 miles long. To be mined by British with British mines (horn type). Barrage to consist of three "systems," each system to have a line of mines at each of 5 depths—65, 95, 125, 155, and 185 feet. Total requirement 67,500 mines.

(*f*) Area C: Eastern area, about 60 miles long. The British plans paper, Appendix I, stated: "It is desirable that American mines should be used for this area, as the number of sinkers required is thereby reduced considerably. A decision on this point can only be arrived at when it is known what type of sinker can be used with the American mine." This, taken in connection with the British inquiry of October 17 as to whether the United States could supply sinkers for United States mines, which was answered in the affirmative, left no doubt in the minds of department and Bureau of Ordnance officers concerned that the United States would mine Area C. Required, 18,000 American mines.

The following additional points set forth in the above-mentioned British paper were taken at their face value by American officers, especially since these points were in accordance with the original American proposition:

(*g*) The mine field must be guarded.

(*h*) The mine field should be as far from the enemy ports as other considerations will permit to enable our patrols to intercept any submarines damaged but not sunk outright by our mines. This implies the maintenance of a patrol.

(*i*) The barrage must consist of both deep mines and mines near the surface; or, if deep mines only are used, the barrage must be patrolled in order to force the submarine to dive to the level of the deep mines.

(*j*) It is also an advantage if the barrage is in such a position that our main fleet can be based on the enemy side of it, as this will not only give freedom of movement to our own fleet, but in addition should enable us to intercept any enemy vessels which endeavor to interfere with our barrage or the vessels patrolling it.

(*k*) The line from Aberdeen to Norway is preferred for the following reasons:

(*a*) Its great distance from the enemy ports.

(*b*) The line is shorter than any other, with the exception of the Orkney and Shetland-Norway line, which is considered impracticable, owing to the depth of water and the strong tides in the Fair Island Channel.

(*c*) The grand fleet, if based on Rosyth, is on the enemy side of the line.

(*d*) Any submarines damaged by mines will have a long way to get home and should be accounted for by our patrols.

(*e*) Whether Norway eventually comes in on the side of the Allies or not, the eastern end of the line will be far easier to guard than the northern end of the Goodwin-Jutland line, which has been suggested.

(*f*) It would be easier to bring pressure to bear on Norway to induce them to take steps to prevent submarines passing through their territorial waters than it would in the case of Denmark with their ever-present fear of invasion.

(*g*) The line Aberdeen-Norway deals with submarines using the Baltic exits as well as with those coming from North Sea ports.

The British version of the plan differed from the American proposition in one most important particular, namely, that the eastern part of the barrage, Area C, was to be deep mined only, leaving the surface safe for traffic and depending upon patrols to prevent the passage of enemy submarines. This part of the plan was foredoomed to failure, since it was obviously impossible for patrols to effectively guard such a large area, as had been demonstrated by British experience in the much smaller area of the Strait of Dover; but for the time being the plan was accepted by American officials, with the understanding that, in case this part of the plan should prove ineffective, surface mining could be extended through Area C later.

It was on the basis of the above understanding of the project that the Bureau of Ordnance proceeded with the design and procurement of the required mining material and that the Navy Department undertook all other necessary preparations for the project. The planting of the barrage was to begin as soon as possible in the following spring, 1918, to assure its completion during favorable weather of the summer or early fall. Therefore, there was little time in which to complete the details of design of the new mines, launch the huge manufacturing project, and obtain production in adequate quantities not later than February, which was necessary in order that the mines could be shipped abroad, assembled, and made ready for use by April, 1918.

Chapter V.

COORDINATION OF PREPARATIONS.

To insure a proper coordination of all necessary preparations for the northern barrage project, Capt. R. R. Belknap of the Office of Naval Operations was placed in immediate charge in that office of the plans for the entire operation, which involved in greater or less degree all bureaus of the Department. The Bureau of Ordnance was to furnish the mines and mining material; the Bureau of Construction and Repair was chiefly concerned in the structural conversion of certain merchant ships into minelayers; the Bureau of Navigation had to furnish the officers and men to man the new mine squadron; the Naval Overseas Transport Service was to allocate sufficient cargo tonnage to maintain adequate and regular shipments of mining material; the Bureau of Supplies and Accounts was to take measures to handle the shipments of mines and other material; and so on.

All the above and other preparations constituted only one of the major naval operations then in hand; and there was the possibility that some essential part of the preparation might not be given its due precedence, either within the department or at some navy yard, unless the various activities were carefully watched and their importance kept constantly to the fore. This was all the more necessary by reason of the fact that the new mine and its objective use were shrouded in mystery, very few officers being let into the secret, which it was hoped could be kept from the enemy until we were ready to begin actual mining operations in the North Sea.

Throughout these preparations the project was mentioned in writing as little as possible, information and instructions to those concerned being communicated orally so that secrecy might be assured.

It was principally by means of informal conference between officers concerned that the many bureaus and offices quickly and effectively solved the multitudinous problem incidental to such a project. "Red tape" and formal routine methods were for the time being abolished, and those officers immediately charged with the work of preparation were practically accorded carte blanche.

In this connection, it is pertinent to note that the Secretary of the Navy, at the time of the project's adoption, stated that it had the strong interest and approval of all in high authority; that he himself desired every effort made to expedite it; that all who might be called upon for assistance should be informed of his wishes in this regard so that they should cooperate to the fullest extent; and that he should be immediately resorted to in any case where his action or influence might be needed.

Chapter VI.

DESIGN OF THE MINE.

The possibility of the northern barrage depended upon the successful design of the new mines to a far greater degree than is usual in such matters. Had nothing better than the ordinary type of mine, such as that used by the British, been available, the northern barrage project would have been utterly impossible of execution within the time allowed by reason of the enormous number of mines required for a barrage 280 miles long. The combined resources of the United States and the Allies, especially in the matter of high explosives, could not have produced the required number of mines, nor could the combined mining forces have planted them in a single year. By the use of mines of the American (antenna) type, the number required was reduced to approximately one-third; and the project became possible, provided always that the design of the new mine was right.

On November 1, 1917, after the barrage project had been finally and definitely adopted, the only parts of the Mark VI mine that had been completely designed were the firing mechanism and the mine case. However, the mine section of the Bureau of Ordnance, under the immediate direction of Commander Fullinwider, felt no doubt of its ability to complete a satisfactory development of the new mine and to get it into production in due time, its optimistic view of the situation being based on the facts that the only radically new element of the mine was the firing mechanism, which had been fairly well tested; that the war experience of the British had evolved a satisfactory type of mine anchor which doubtless could be adapted to the American mine; and that the remaining features were matters of mechanical detail certainly susceptible of quick solution. In the circumstances, it was absolutely necessary to take chances, else the project would be delayed a full year and therefore be too late. It was fortunate that Rear Admiral Earle, the Chief of Bureau, was willing to accept the final responsibility in this matter and that he had sufficient confidence in the mine section to give it practically a free hand.

If the Bureau had been at all conservative in the matter of developing the design and placing contracts for the mines, the northern barrage would never have been laid. It is a well known fact

that no mechanism as complicated as a mine, or even a much simpler one, can be confidently expected to function as designed until complete models have been tested under service conditions and the usual minor defects have been discovered and remedied. Ordinarily, it requires at least a year to prove out such a design before it is considered wise to put it into production. Judged by ordinary standards, the action of the Bureau in bringing about the adoption of this great project before there was any certainty of the efficiency of the new mine, thereby committing two Governments to very large expenditures, was, to say the least, hazardous. The Bureau accepted the hazard advisedly, as the only thing to be done in the circumstances, and well knowing the odium that would attach in case of failure.

The problem confronting the Bureau was to build a mine around an entirely new principle in mining, and around a firing gear outlined but not perfected. This mine must be efficient and yet must be capable of manufacture and assembly in great quantities, with as little expense of money as practicable, and necessarily with as little expenditure of time as absolutely possible. The bureau had departed from the usual, or contact, mine with its new firing gear, and had then proceeded to wipe the slate clean and make radical developments in the entire mine.

Practically all mines, except the later German types, had been made up to that time with the explosive in separate charge chambers, which were, after loading, placed within the mine case proper. This presented the triple disadvantage of additional weight; cost of time and money in manufacture, loading, and assembly; and, most serious, the interposition of an air cushion surrounding the charge chamber between the first explosive force and the water, thereby greatly reducing the force of the water hammer blow caused by the explosion, which blow was that relied upon to damage the submarine touching the antenna. These difficulties were all obviated by selecting an explosive, T. N. T., which could be readily cast and cooled, and casting this direct into the completed mine case, using no separate charge chamber.

In addition, similarly the practice of carrying the detonator fixed in the explosive was a source of great danger in case of accident or fire or in case the minelayers were engaged in action with the mines on board. The safety chamber device of service fuses was adopted, so that the detonator might not be in contact with the main explosive until after the mine had been launched and submerged.

The design of antenna gear presented a problem that had, as far as was known, no precedent in the military or commercial arts, and required considerable initial design ability and experimentation.

As a matter of fact, the officers responsible for the mine freely admitted to themselves the certainty that the design would have to be modified more or less after service tests, and therefore shaped the design so that any one of its features could be modified during production with little or no effect on the others. In other words, every possible precaution was taken against possible loss of time and money. The result was very satisfactory. Very few changes were necessary after getting into production, and when the first complete mines were assembled and tested under service conditions in March, 1918, they functioned as designed, and only very minor improvements, involving no delay in the project, were found to be desirable or necessary.

During the initial plans for the mine, the mine section of the bureau consisted of Commander S. P. Fullinwider, Lieut. (subsequently Commander) J. A. Schofield, U. S. N. R. F., and, acting as the experimental officer of that section by virtue of his experimental duties in the bureau, Lieut. T. S. Wilkinson, jr. As the project began to take shape and became approved, the bureau added to the mine section certain line and reserve officers, who will be mentioned hereafter as their duties appear.

In the initial stages of design, Commander Fullinwider assumed cognizance of the mine case, anchor, and antenna gear, leaving Lieut. Wilkinson the firing gear, the extender, and the mine loading; that is, explosives and detonator. With the advent of other officers these duties were further subdivided as follows: To Commander Schofield, the mine case; to Lieut. O. W. Bagby, U. S. Navy, and Lieut. S. W. Cook, U. S. N. R. F., the mine anchor, in conjunction with Lieut. Commander H. Isherwood, R. N. V. R. (noted below); to Lieut. Commander W. A. Corley, U. S. Navy, the antenna gear; to Lieut. C. H. Wright, U. S. Navy, the firing gear and extender; to Lieut. B. W. Grimes, U. S. N. R. F., the explosives. This division of responsibilities held through the design stage and through the production of the parts of the mine, as described in the succeeding chapter of this history.

At various times during the period of design and experimentation, the Bureau of Ordnance had the advantage of the advice and assistance of three experienced mining officers of the British Navy. On May 5, 1917, Lieut. Commander H. O. Mock, R. N. V. R., arrived in the bureau, having been thus assigned by the British Admiralty, to assist and advise in matters pertaining to mines. This was in accordance with a plan adopted immediately upon the entrance of the United States into the war, whereunder each of the two naval departments undertook to furnish the other with information to their mutual advantage. Lieut. Commander Mock brought to the Bureau of Ordnance the latest information and experience regarding

the British mines and mining, more particularly information concerning mine anchors.

During Lieut. Commander Mock's stay in the bureau, the Mark VI mine-firing device (K–1 device) was evolved; and he was present during much of the experimental work in connection therewith, although he did not assist in the evolution of the design. He was an early convert to the value of the new device; and upon his return to England in October, 1917, a model of the new device was transmitted by him for the Admiralty's information, the question of whether or not the British would join the Americans in the barrage project being then under consideration. Lieut. Commander Mock considered the K–1 device of great promise, and looked upon the new mine then in process of evolution as being superior for purposes of anti-submarine warfare to any other then existing type.

Lieut. De Salis, R. N., arrived September 3, 1917, having been sent to this country to examine the Mark VI mine and report to the British Admiralty as to its probable value for the proposed North Sea barrage. He was sent to this country on the initiative of the British Admiralty and apparently with a view to satisfying the Admiralty that our Navy Department really had what it had previously stated it had—a mine superior to existing types and peculiarly adapted to antisubmarine warfare. In short, the British Admiralty took this means of confirming the Bureau of Ordnance opinion and estimate of its own design and product before agreeing to cooperate in the establishment of a barrage.

After Lieut. De Salis had reported to the Chief of Bureau on the above-mentioned date, the chief of the mine section explained to him the characteristics of the new mine firing device, and accompanied him that evening to the naval torpedo station, Newport, R. I., to witness tests. These tests were carried out, with inadequate preparation and facilities, on the two following days, September 4 and 5. Lieut. De Salis was soon convinced that the new device had merit. On September 7 he cabled the Admiralty in part as follows:

The mechanism is safe and simple. Still in trial stage. It has worked perfectly for safety and bumping. No vessel really suitable was present, so trials were rather crude. Trial of countermining was not very satisfactory, but the faults revealed can be remedied.

Mine designed is 33-inch diameter, and could be used with B. E. or Mark VI sinker. A 38-inch diameter mine would be designed if desired. No sinker is yet designed and it is intended to copy ours.

U. S. officials state that delivery of a thousand mines and mechanisms per diem is anticipated to commence December 1.

Proposals are that combined operations should be worked out for use of these mines. They would provide the mechanisms and mines, while the British provide minelayers and sinkers.

They offer a hundred thousand. Details of strategical proposals are known to Admiral Mayo.

It is recommended that American offer should be accepted, our own output not being decreased in consequence.

The questions to be settled subsequently are manufacture of sinker, size of mine, and supply of explosive. They have sufficient crude T. N. T. and are willing to supply it.

I still adhere to the opinions expressed September 3, but advantages to outweigh them are: Simplicity, certainty of firing, large danger zone, and the element of surprise if the secret is kept.

On September 10 the Admiralty cabled Lieut. De Salis:

Greatly appreciate offer of U. S. Fully recognize the value of the increased danger zone near mines, but fear is expressed that if antenna only can fire mine, life in this climate would be limited by durability of antenna, which is necessarily short.

Reply forthwith if antenna principle can be applied to horned mines, whose plans are now in America; or, conversely, if American mines can be fitted with a firing arrangement thoroughly reliable, or with horns so that effectiveness as complete mines would remain after antenna has parted.

Lieut. De Salis, after consulting the Bureau of Ordnance, replied, September 11:

Americans propose to fit fixed insulated projections of copper on mine case in parallel to antenna, so that mine will remain effective on same principle if it is hit whether the antenna is in place or not. Firing battery will then determine life of mine. It is sealed up, and no current is taken from it until moment of firing.

On September 12 Lieut. De Salis again cabled the Admiralty, in part as follows:

United States officers are extremely confident as to life of battery. In addition, halfway down antenna a float will be fitted, in which case wave action should not much affect lower half.

Acceptance of the offer as it stands is strongly recommended.

Design could subsequently be altered for fitting horns should endurance trials, which are now in hand, prove unsatisfactory.

Admiral Benson wishes to be informed of the proposed strategical use which may be decided on if offer is accepted, and of the numbers required.

The Bureau are requesting that a mine designer may be lent them to cooperate and insure fitting of mine on sinker.

Lieut. De Salis, during his connection with the Bureau of Ordnance, was an observer for the British Admiralty and probably had much to do with the Admiralty's favorable consideration of the proposed joint project. In addition, Lieut. De Salis furnished the bureau information of a general nature regarding British mines, mining equipment, and mining practice. He did not, however, have any influence on the design of the Mark VI mine. Lieut. De Salis spent much of his time at the naval torpedo station, Newport, where he conducted some tests with floats and antennæ. He returned to England in December, 1917.

In the original proposition for a joint American and British barrage operation, it was proposed by the Bureau of Ordnance that the

British should furnish the anchors and that the United States should supply all the mines. This proposition was put forth for several reasons: First, there was a shortage of tonnage available for the shipment of the material abroad, and this shortage was growing more and more serious from day to day as the result of the great activity at that time of the enemy submarines. The dead weight of the anchors alone required for the barrage was estimated at about 40,000 tons. Second, the British had a quite satisfactory type of anchor, which had been proved out during the war, and which, with minor modifications, could be adapted to fit the American mine. Third, it was originally contemplated that British mine planters would assist the United States mine force in the planting of mines, and therefore the mine tracks and mining equipment in general should be standardized in the two services. Fourth, it was considered only fair that, if the barrage was to be a joint operation, the British should bear a share of the cost and production of material.

After much delay in arriving at an understanding, it was finally decided to produce all the anchors as well as the mines in this country. To facilitate the design of the anchor, and particularly with a view to making it standard with British mine layers' equipment, the British Admiralty was requested to send an officer to the Bureau of Ordnance who was competent to modify the British design of anchor to adapt it to the Mark VI mine. The admiralty properly acceded to this request, and Lieut. Commander Isherwood, R. N. V. R., arrived in the Bureau early in October, 1917. He brought with him the detailed design of the British Mark VIII sinker (mine anchor), and this was found upon examination to require very little modification to suit the Mark VI mine. Lieut. Commander Isherwood, with the assistance of Bureau of Ordnance draftsmen, completed the redesign of the British sinker, referred to hereafter as the anchor, Mark VI; and on November 10 the design was ready for submission to the prospective bidders.

While the Mark VI anchor was very similar to the British Mark VIII sinker, it differed in detail sufficiently to have warranted thorough tests before its adoption, had the time been available. However, as not a day could be lost without correspondingly delaying the execution of the project, it was decided after very careful study of the design that it would be reasonably safe to proceed with production; and contracts were placed immediately with three prominent automobile concerns in Detroit, Mich. Lieut. Commander Isherwood remained in the United States until the anchors were well along in production and until after practical tests with complete mines had been carried out by vessels of the mine force just prior to their departure for the North Sea. The anchor proved most satisfactory in every respect, being, it is now believed, superior in its functioning to the British Mark VIII sinker from which it was adopted.

The mine case was entirely a Bureau of Ordnance design. It was formed of two hemispheres of steel welded together at the equator. It had an opening in the top 7 inches in diameter to receive the firing gear, and a smaller opening in the bottom to take the booster charge and the detonator extender mechanism. Built into the lower hemisphere, in the axis of the case, was a steel tube which housed the booster charge and extender mechanism. The charge of 300 pounds of grade B trinitrotoluol was cast directly into the lower hemisphere of the case, it being found by experiment that the charge was sufficiently anchored in place by the bond between it and the surface of the case and central tube and by four stay braces which supported the tube. This simple form of construction saved considerable weight and permitted of the mine case being kept within comparatively small dimensions—34 inches diameter. The British mine had a diameter of 38 inches. The buoyancy of the Mark VI mine was 285 pounds, which is ample for mines to be used where the current is not greater than three knots. The mine case had welded to it a lifting eye, also hooks for securing the antenna system and the anchor. Four small holes in the case about 2 inches above the equator were provided for attaching firing "horns" in parallel with the antenna.

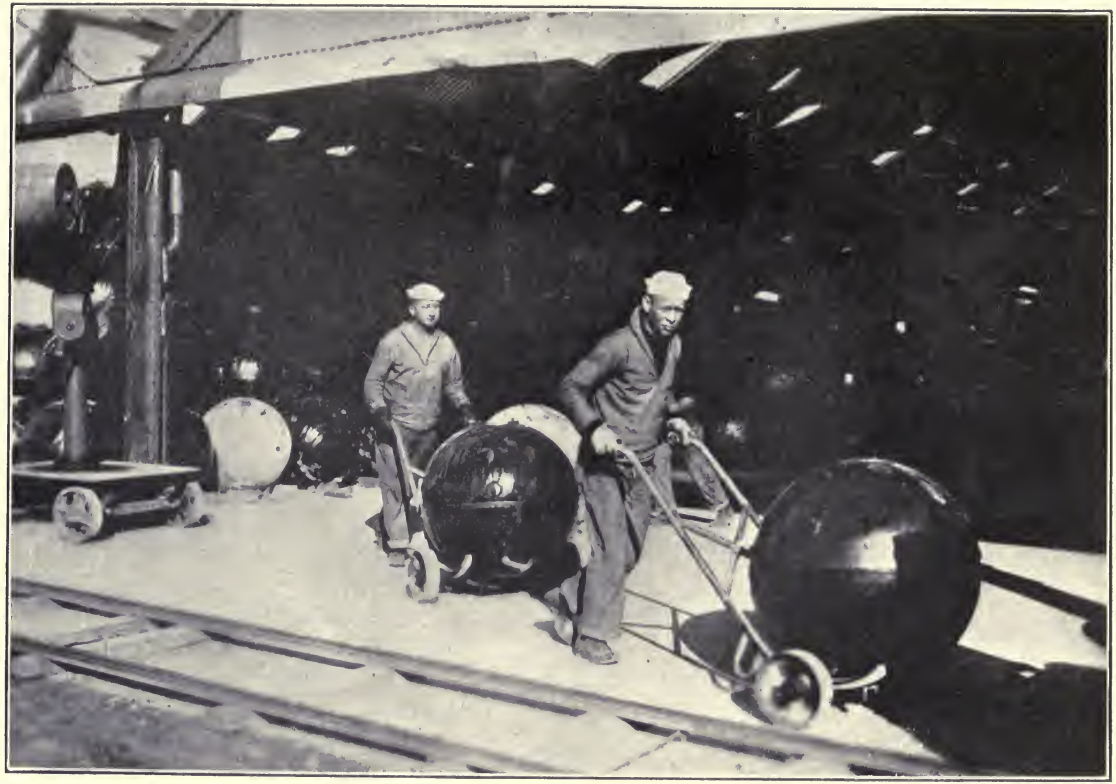
The extender mechanism, which carried the detonator in a retracted or safe position relative to the booster charge, and which, under a hydrostatic pressure corresponding to a depth of 25 feet, extended the detonator to its firing position in the axis of the booster charge, was a lazy-tongs device, which also was originated and designed in the mine section. This mechanism provided an excellent safety device, since a mine which floated or which was submerged to a depth less than 25 feet would be safe.

A similar hydrostatic safety device was incorporated in the firing mechanism; and both of these devices would have to fail to make the mine dangerous on or near the surface.

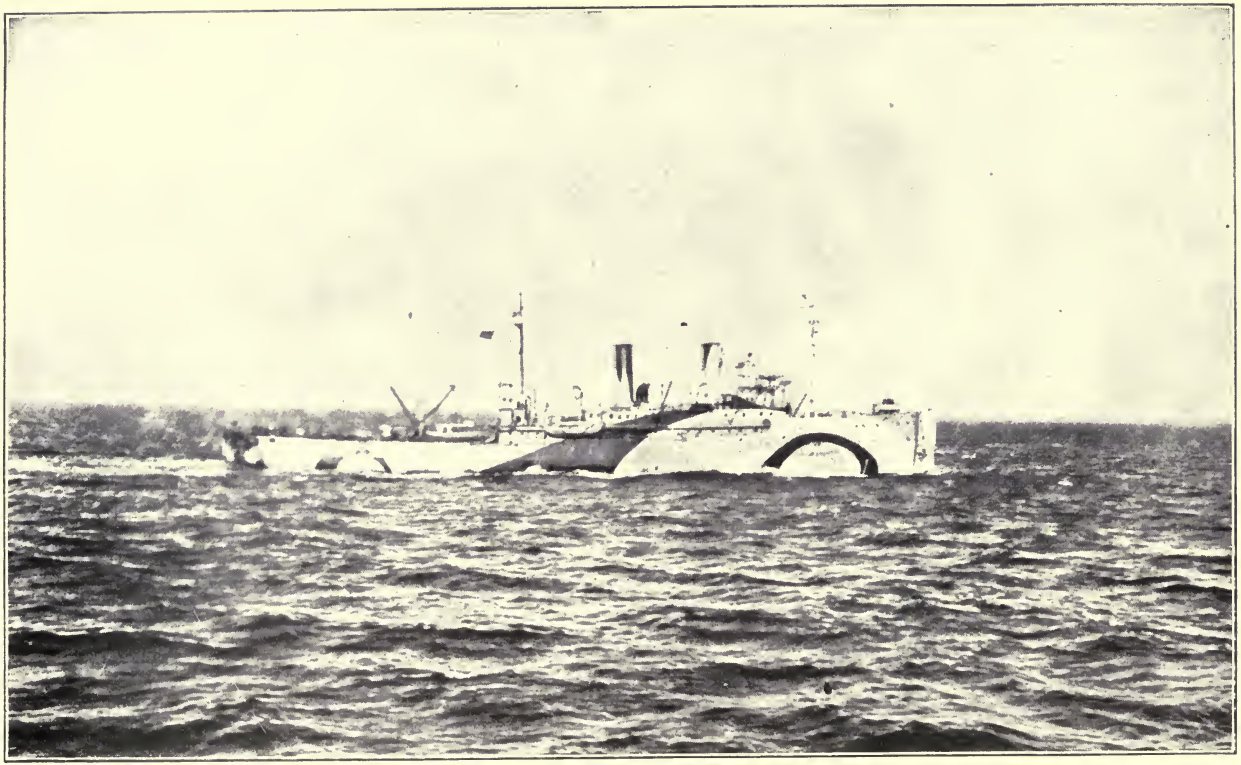
The antenna floats, the fittings in connection therewith, and the means of assembling the antenna system with the mine proved the most troublesome parts to design though they appear very simple. Experiments were first made with floats of water-proofed wood, but without success, since it was found impracticable to guard against their water-logging when subjected to deep submergence for considerable periods. Ultimately, three different types of float were successfully produced and used. For mines of the upper level a thin walled spherical copper float was used; for mines submerged 150 to 300 feet a spherical-cylindrical steel float with a wall thickness of 0.1 inch was used. The third type, which finally replaced the copper floats was made up of balsa and skillfully waterproofed to withstand hydrostatic pressure safely up to at least 100 feet submergence. For mines of the upper level, two floats were fitted on each antenna, the

TUG TOWING BARGES TO MINELAYERS IN THE HARBOR OF INVERNESS, SCOTLAND, SEPTEMBER, 1918.
(Page 68.)

(Page 68.) A FLEET OF MINES, NORTH SEA.



HANDLING MINE CASES. TRUCKING MINE SPHERES FROM THE BULK STORES TO THE ASSEMBLY SHEDS.
(Page 69.)



(Page 75.) U. S. S. SHAWMUT, MINELAYER IN THE NORTH SEA, CAMOUFLAGED.

lower one being placed a little above the middle point of the antenna, so that, in the event of the upper float carrying away, no part of the antenna could possibly come into contact with the mine case and fire the mine.

The antennæ of the lower level mines were provided with a single steel float. These mines were at such depth as to be entirely unaffected by wave motion, and one float could be depended upon for an indefinite life.

The mechanism by means of which the antenna and floats were secured to the mine case until the mine reached a predetermined depth and then permitted their release in such a way as to avoid fouling, gave much difficulty, but the problem was very satisfactorily solved with the assistance of the *Baltimore*.

Discussion of many of the items of design, including that of the K–1 device, or firing mechanism, is omitted here as unnecessary and because they are still regarded as confidential.

One of the most important and indispensable of the preparations was the trying out of the new mine under service conditions. In the earlier stages, complete mines were not available; and they did not become available until March, 1918. In the meantime, however, the *Baltimore*, which had been designated to carry out tests, performed such experiments as could be had with improvised material, and assisted in the design of some parts of the gear, notably the means of assembling the antenna floats with the mine and their release gear. This work continued until about December 20, 1917, when it became necessary for the *Baltimore* to go to the yard for fitting out for service abroad. It had been intended that this vessel should resume experiments and practice with the completed mines in March, but before that time it became necessary to send her abroad to assist in a British mining operation.

The mine trials were taken up by the *San Francisco* in March when the first mines were ready. Trials were carried out in the lower Chesapeake, later in Narragansett Bay, and finally off Cape Ann. The results of these trials were all that could be expected. With the exception of a very few minor mechanical faults which were readily corrected, the mine and anchor functioned as designed; and the action of the Bureau of Ordnance in having proceeded with the manufacture of 100,000 mines in advance of such tests was thus validated. A most important result of the trials was the confidence engendered in the personnel of the mine force in the value and safety of the new mine.

It may be remarked in passing that the result of the trials lifted a heavy load from the minds of those officers of the Bureau of Ordnance who had staked all on a "paper design" and proceeded with an enormous manufacturing program in advance of complete tests.

Chapter VII.

THE MANUFACTURING PROJECT.

The firing mechanism for the new mine was in quantity production before any other part of the mine had been designed. The mine section had made tentative sketches of the several principal features of the mine, but none of the details had been decided upon. One reason for this was the fact that until the firing mechanism had been conclusively tested and adopted, late in July, there was insufficient information and data on which to proceed with the other points of design. Another point was that until November, 1917, there was insufficient personnel in the mine section to perform the duties of the Bureau pertaining to mines and mining, depth charges, submarine nets, etc.

The Bureau of Ordnance, having anticipated the favorable outcome of the mine barrage proposition had placed a contract for 10,000 mine-firing mechanisms (K–1 devices) as early as August 9, 1917, and another contract for 90,000 additional devices on October 3, 1917, nearly a month before the barrage project was definitely adopted.

In view of the fact that there were so many uncertainties entering into the design of the mine, it was decided that the only safe plan was to follow the practice which is quite common in the automobile industry—that is, to divide the mine into groups of parts, each group being quite a separate design problem, all so standardized that the several groups would assemble into a complete mine. Thus the mine was separated into the following groups: Firing mechanism, extender mechanism, mine case, anchor, antenna and floats, horn device, and release gear.

Each group was designed and tested out quite independently of the others, a very definite general plan for the mine, of course, being kept in view. This method permitted of modifications of any one group without detriment to the others.

Another reason for following this method of design was that it would facilitate manufacture. There was no plant in the United States that had had experience in the manufacture of mines except the Norfolk Navy Yard, which yard was overwhelmed with other work after the outbreak of the war and could not be depended upon for any considerable manufacture of mine material. By designing the mine as an assembly proposition, its many parts could be manufactured in commercial plants with great rapidity; and by carefully

standardizing all parts, they could finally be brought together and satisfactorily assembled.

The general economic conditions of the country were such that at the time when it became necessary to manufacture the Mark VI mine the passenger automobile industry became available for war work through a gradual decrease in output of automobiles. It is believed that the Bureau of Ordnance was the first of the war agencies to take advantage of the wonderful resources of the automobile factories; and no difficulty whatever was found in obtaining keen competition among these factories for the manufacture of parts. Generally speaking, the automobile plant is ideal for the production of mine material with the exception of the firing mechanism, because the plant is organized for quantity production and the character of work and workmanship is practically the same for automobiles and mines.

Still another reason for pursuing this method of manufacture was that only by this means could secrecy regarding the characteristics of the mine be preserved. It is obvious that if 100 different parts of a mine are manufactured by as many different factories, most of which are kept in ignorance of the fact that they are producing mine material, no one would have sufficient information on which to visualize the complete mine, and therefore no one could possibly betray the secret to the enemy. This idea was carried still further. Even at the point of assembly of the material for transshipment abroad, the parts were not assembled into a mine, but were shipped in groups to the overseas assembly bases. In short, no mines were completely assembled in this country, with the exception of a few for test purposes on board vessels of the mine force in March, 1918. It is therefore believed that the enemy, notwithstanding his many sympathizers in the United States, and his secret service, had no inkling of the character of the mine until long after it was placed in use in the North Sea. It was comparatively unimportant to maintain secrecy after the mines were once in use, for it was probable that the enemy could not devise any means of effectively counteracting or protecting himself against the mine within, say, a year after he gained knowledge of it, by which time it was expected that the war would be over. In this connection, it may be stated that a number of American mines went adrift in the North Sea, as is usual in such operations, and were cast up on the coast of Norway, where they were recovered, disassembled, and examined by Norwegian officials, but assurances were obtained that information regarding these mines would be regarded as confidential.

The firing mechanism has been referred to above as a unit of the assembled mine; but, as a matter of fact, it was subdivided into its component parts and manufactured by more than a score of different

factories, none of which was permitted to know that it was manufacturing mine material. Only certain officials of the private plant that assembled the firing mechanism knew that it was intended for a mine.

The Mark VI mine was designed to be very safe in handling; and that this object was attained is well demonstrated by the fact that 85,000 of these mines were loaded and shipped abroad and that about 57,000 of them were planted in the barrage without accident. This result is the more extraordinary for the following reasons:

(*a*) The mines had to be manufactured by quantity production methods, and rigid inspection was quite impossible under the then existing conditions.

(*b*) The inspection force was inadequate in numbers, and it was composed largely of inexperienced officers and men—inexperienced not only in mine material but in inspection work in general.

(*c*) The manufacturers were inexperienced in munitions work, and almost every one of the hundreds of plants engaged in the work was an unknown quantity as to reliability, quality of product, possibility of sabotage, etc. Due investigation and careful "sizing up" of the managing personnel of each plant concerned reassured the Bureau in almost every case.

(*d*) The mine had to be loaded, shipped, assembled, inspected, and tested by personnel almost entirely without previous experience with mines and explosives.

It was owing to these adverse conditions, together with the fact that the mine was to be handled by the minelayers as "fixed ammunition," that it was designed to be as nearly foolproof as possible.

During the period of purchasing supplies, in the task of which there was a multitude of details, Lieut. (j. g.) A. B. Peacock, Supply Corps, U. S. Naval Reserve Force, handled the purchasing matters connected with this vast amount of divers materials, a duty that required his working in close co-operation with the mine section of the Bureau.

The design and manufacture of the various elements of the mine was a work involving an immense amount of detail, which it is unnecessary to dwell upon here; but a few points are of special interest in their bearing on the success of the project.

It has been mentioned above that the new mine was designed to be issued to minelayers as "fixed ammunition." This was a radical departure from conventional practice, and British mining officers attached to the Bureau apparently never became reconciled to the Bureau's view that practically all necessary tests and inspection could and should be made prior to the receipt of mines on board. The new idea was adopted primarily because of the obvious necessity for rapid laying, the number of minelayers being limited. After having

become committed to this plan, it was fairly easy for the Bureau to design, manufacture, and inspect accordingly. For example, the mine case was designed to be as simple and foolproof as possible, and it was given 100 per cent inspection at the factories for watertightness; so there was no good reason for subjecting the case to another such test at the overseas bases or after its receipt on board ship.

Another point to which the Bureau gave careful attention was to insure that, in the event of a premature or accidental explosion of a mine, it would necessarily occur only after a safe interval after launching. As for taking mines aboard ship with the detonators in place, the bureau adopted this plan only after conclusive tests had shown that a detonator in the "safe" position could not explode the charge.

The well-known fuel shortage in the winter of 1917–18, the almost unprecedented severity of the weather, the freight embargoes on the railroads and congestion of traffic generally, and labor troubles, all operated to delay the production of mine material and other essential preparations for the project. The situation was very critical for some weeks, largely because these conditions affected several hundred plants engaged, and the failure of any one of them to produce its share would have resulted in possibly disastrous delay to the whole project. Some delay did, in fact, result, but as there was a nearly corresponding delay in the completion of vessels of the mine force and of the overseas bases, the failure to meet the manufacturing schedule proved of no particular consequence. It is estimated that the above-mentioned adverse conditions resulted in delaying the beginning of quantity production of complete mines about six weeks.

During the period of railroad freight congestion an immense quantity of mine material was handled by express shipments, in some cases whole trainloads being handled on passenger schedules from Detroit to the seaboard. It is believed that every known expedient was utilized to maintain production and expedite shipment—armed guards and traffic agents accompanied shipments; motor trucks were used when other service was unavailable; freight embargoes were lifted after great effort in special cases; tracing of missing shipments was a constant work; and shortage of fuel was met and overcome in many ways.

There was only one real failure of an important contractor to deliver material on time, and this resulted in a slight delay in mining operations. It was an almost invariable rule of the Bureau to divide the order for any one part of mining material between at least two contractors, in order to guard against a possible failure on the part of a contractor and consequent shortage of essential material. In

the one case in which this rule was deviated from, the article being a comparatively simple one and the contractor being apparently more than able to meet his obligations, the contractor failed to deliver the specified production, and it then became necessary to tool up three other plants and cancel the original contract.

The Bureau planned for a production of 1,000 mines a day, and it was found soon after getting into production that this rate could easily be exceeded if desired. In fact, it became difficult to hold the production of anchors and mine cases down to this figure. In other words, the Bureau could have produced mines at any rate desired, except possibly in the matter of mooring cable, the wire rope manufacturers being heavily burdened with orders for wire for aircraft, shipping, coal mines, etc.

Chapter VIII.

MINE-LOADING PLANT, ST. JULIENS CREEK, VA.

An important item of preparation for the barrage project was the creation of a complete mine-loading plant capable of receiving, loading, and shipping 1,000 mine cases a day, there being no plant in the United States at that time capable of handling any considerable number of mines.

The design of a plant that could handle the situation had to be made by the Bureau of Ordnance and the Bureau of Yards and Docks in consultation. Many proposals were sent out in order to obtain ideas upon automatic machinery, and finally a plan, modified somewhat after a scheme suggested by Boyle-Robertson Construction Co., was accepted and completed. The plant was built by the Boyle-Robertson Construction Co., of Washington, D. C. Commander Kirby Smith, Civil Engineer Corps, United States Navy, was responsible for pushing to completion, in the midst of many difficulties, both in design and construction, this mine loading plant.

It was decided to locate this plant near the navy yard, Norfolk, Va., the point selected for the assembly and shipment overseas of all barrage material; and the only immediately available site being at the Naval Ammunition Depot, that point was chosen. Ground for the plant was broken on October 25, 1917; but bad weather set in early in November and continued with unprecedented severity until spring, so construction work was carried on under most adverse conditions. Aggravating the situation, there was a labor shortage. However, the plant was ready for work in March, 1918, or practically as soon as needed, there having been delays in all parts of the project due to extreme weather conditions, freight embargoes, fuel shortages, labor troubles, changes of barrage plan, etc.

This plant, with its accompanying barracks for the housing of its operatives, covers an area approximately 3,000 feet by 800 feet, including the wharf, and consists of 22 buildings, including a mine case storage building, 600 by 100 feet, capable of storing 5,000 empty cases; a melting plant, capable of melting and pouring T. N. T. for at least 1,000 mines a day; a cooling building, where the loaded mines were permitted to cool preparatory to shipment; a T. N. T. ready-storage building, capacity 4,000,000 pounds; a heating plant; and a wharf.

The entire plant was excellently equipped with conveyors and labor-saving facilities; and all parts were planned and constructed to give the utmost efficiency consistent with safety. The rated daily capacity of 1,000 was exceeded by about 50 per cent on one occasion; and a total of more than 73,000 mines, involving the melting and handling of over 22,000,000 pounds of T. N. T., were loaded here without accident. In addition, 17,000 mines loaded by contract at the du Pont Co.'s works at Barksdale, Wis., were received here and shipped abroad.

The loading plant cost approximately $400,000, and its operating cost was at the rate of about $412,000 per annum. About 400 enlisted men were required to man the plant; and, in addition, from 200 to 400 were employed in the shipment of mines, that is, in loadthem into mine-carrying vessels.

A loading plant of this type and scale had hitherto been unknown, not only in this country, but abroad. Difficulties were encountered in the construction thereof; and prophecies of accident, fortunately unfulfilled, were made by visiting foreign experts skilled in amatol plants. The Bureau of Ordnance, however, took every precaution to insure that the operation of this plant should be attended with the minimum amount of danger. The Chief of the Bureau took upon himself the limiting of the steam pressure to a maximum which he considered, from his experience with explosives, would result in satisfactory melting of T. N. T., and thus loading the mines, but reduced the danger of detonation in the process to the minimum possible. Exact knowledge upon this point is not yet to be had, as experience with this explosive has been too short to permit real conclusions. This decision was one that was very serious, as he had before him the fact that, in the melting of high explosives abroad, a detonation that destroyed an entire plant together with every person in the same had occurred, and that the proposed automatic operation of loading mines was in a nature exactly similar to the work underway in that plant.

Petty officers and enlisted men of the Naval Reserve Force were secured for the operating personnel of this mine-loading plant. They accepted the risk, which they knew was a great one, together with the discomforts—such as working in an atmosphere of T. N. T. dust, working nights, and living in poor quarters in a very bad locality, so far as health is concerned—cheerfully, and with most successful results in the completion of the material for the northern barrage.

Commander W. L. Pryor, United States Navy, was in command of this mine-loading plant in addition to his duties in charge of the ammunition depot at St. Juliens Creek. Much work in connection with loading of mines upon the mine carrier, after the T. N. T. had been cast into the mines, devolved upon Commander Pryor. The success

and general efficiency of the plant was brought about mainly through the untiring efforts and care of Commander Pryor in dealing with the reserve personnel, making them acquainted with the necessity for care and the reasons they were called upon to bear so many discomforts and undergo the risks.

In order to prevent delay in delivery, which might have been caused by delay in completion of this Navy plant, the Bureau arranged with the du Pont Co. to load mines direct at its T. N. T. plant at Barksdale, Wis., and some 17,000 mines were loaded there during the months of February and March, 1918.

The Army had plainly informed the Navy that it required all the toluol in the country for use in the manufacture of its own explosives; and, for this reason, it was imperative, if the mine barrage was to be completed, to secure some other explosive for use in the mines. The explosive effects of amatol, a substitute for T. N. T. in general use abroad, had been frequently criticised for lack of effectiveness. Amatol also required more toluol than the Navy could obtain without asking the Army to reduce its requirements. E. I. du Pont de Nemours & Co. proposed to the Bureau the use of trinitroxylol, which could be produced by the nitration of xylol, a by-product of coal tar distillations, at that time not widely used. Further investigation by Lieut. Commander T. S. Wilkinson, United States Navy, in collaboration with chemists of E. I. du Pont de Nemours & Co., finally developed the fact that trinitroxylol was an explosive substance which would serve very acceptably as a diluent for T. N. T., and that the use of a mixture of these two substances in mines would be practically as satisfactory as the use of T. N. T. alone (the mixture adopted consisted of 60 per cent trinitroxylol and 40 per cent of T. N. T.), although the mixture was not quite as convenient to handle as T. N. T. Trinitroxylol was subsequently known as T. N. X.; and the mixture of T. N. T. with T. N. X. for mine charges was called toxyl.

Chapter IX.

ASSEMBLY AND SHIPMENT OF MINE MATERIAL.

Since the Mark VI mines were not to be assembled short of Bases 17 and 18 in Scotland, and since all component parts had to be at all times available at those bases, it was essential that the flow of all material from the many points of manufacture to the overseas shipping point, Norfolk, and thence to the bases abroad should be maintained at the proper rate. Failure in this respect would result either in a shortage of material and consequent delay of the planting operations or in a congestion of an undue amount of material which could not be stored and properly cared for.

At the inception of the movement it was decided between the Bureaus of Ordnance and Supplies and Accounts that it would be necessary to commandeer one of the large export terminal piers in the vicinity of the navy yard, Norfolk, for the handling of mine shipments; and after a survey of the situation Southern Railway Pier No. 4 at Pinners Point, Va., was taken over by the Navy. This pier, which is 875 by 270 feet and which can accommodate seven cargo vessels of the "Lake" type at a time, was ideal for the purpose. It, of course, is roofed over and has adequate rail facilities. The rental of the pier was $81,000 a year, and the annual cost of operation was about $350,000.

When the project was planned, it was contemplated shipping all mine material, including the loaded mine cases, from this pier; but the local authorities protested against the handling of explosives at this point because of the danger to Norfolk and Portsmouth, and it became necessary to load the explosive elements into the mine-carrying vessels at the mine-loading plant at St. Juliens Creek, about 2 miles above the navy yard. To this end considerable dredging had to be done at the mine plant; fixed moorings were put down; and the dock facilities at the mine plant were enlarged and improved to accommodate the carriers. Provision was made for working 24 hours a day at the mine plant and at the pier when necessary. Only Navy personnel was employed. It would have been quite impossible to operate satisfactorily at either the pier or the mine plant with civilian labor, owing to the irregularity of working hours, the frequent necessity of night work in order to get vessels loaded in time to join the weekly convoys, and also the necessity of good discipline, safety, and secrecy.

Pier 4 was used for storage as well as for shipments. It had a capacity of about 40,000 mine anchors and other nonexplosive parts. A naval force of about 400 men was continually employed at the pier.

The receipt and shipment of mine material at the pier was under the cognizance of a supply officer detailed by the Bureau of Supplies and Accounts to that exclusive duty; but the Bureau of Ordnance also had its representative there to act as liaison officer between the Bureau and the supply officer. To this liaison officer were communicated by telephone complete detailed instructions daily as to shipments, not only from the pier, but also the mine-loading plant, such instructions being confirmed to the supply officer in writing. There was never the slightest delay or confusion in the handling of the business, this because of the excellent cooperative spirit and zeal existing among all concerned in the project.

In the mine section of the Bureau of Ordnance, Lieut. Commander H. E. Fischer had, as his principal duty, the maintenance of the flow of material from its source to its final destination. By means of telephone and telegraph he was in constant touch with the material situation from the hundreds of factories to the bases overseas, and his records at all times showed the exact condition of affairs. In all this he acted in close cooperation with the traffic and other offices of the Bureau of Supplies and Accounts as well as with the officers of the Mine Section. He also was in close cooperation with the Office of Naval Operations regarding the loading and sailing of the mine carriers.

Weekly inventory sheets and monthly reports showing receipts and expenditures of mines and parts at Bases 17 and 18 were received, but were not of much value, as they were about one month old when received. Therefore, in order to anticipate shipments, it was necessary to resort to speculation to a very considerable degree. The results were, however, quite satisfactory.

In the inception of the project, the Navy Department secured the allocation of a fleet of 24 cargo vessels of the "Lake" class for exclusive use as mine carriers. These vessels, a list of which is appended, were armed for defense against submarines, were given Naval Reserve crews, and were handled by the Naval Overseas Transportation Service (Operations). They were rather small, averaging about 3,000 tons dead-weight capacity, but by reason of their light draft were well suited to the purpose, since larger and deeper vessels could not have been so readily loaded or discharged at the terminals selected; in fact, the harbor of one of the discharging points designated by the British authorities could not accommodate ships drawing more than 20 feet. The carriers were selected also with a view to carrying a comparatively small number of mines in each hull, so as

to minimize the effect on the whole project in the event of a vessel being lost. Among other preparations requiring navy-yard work was the fitting of these vessels with additional crew accommodations; the provision for additional cargo coal for themselves, as they were originally short-radius ships, and provision of facilities for carrying 300 to 500 tons of fuel oil cargo for naval vessels overseas.

In general, a cargo was made up of 2,000 mines with anchors and fittings complete and of about 500 tons of such miscellaneous naval supplies as were safe to handle in conjunction with high explosives, the remaining 1,000 tons of cargo space being assigned to extra bunker coal and fuel oil, the latter carried in the double bottoms. The mines were shipped disassembled to economize space; but it would have been undesirable in any event to ship them otherwise, in view of the fact that the work of handling, testing, and inspection at the overseas bases was facilitated by shipping them disassembled.

Sailings of the carriers averaged about two ships every seven or eight days, half in Norfolk convoys and half in Halifax convoys. It took a ship in a Norfolk convoy about 20 days to make the trip across, and in a Halifax convoy 21 days. From 65 to 70 days were required for a round trip or complete cycle.

Of the 24 carriers, only one, the *Lake Moor*, was lost, sunk by an enemy submarine off the coast of Ireland on April 11, 1918, unfortunately with the loss of most of her crew, and of about 1,500 tons of mine material, mostly anchors.

Chapter X.

OVERSEAS MINE BASES 17 AND 18.

On account of the great demand for shipping, it was early realized that in order to conserve cargo space, and for other reasons, it would be necessary to ship the mines for the North Sea barrage disassembled. In this manner it would be possible for a vessel to carry approximately three times as many mines as she would have been able to do had she been loaded with assembled units. On the other hand, this procedure necessitated the erection of elaborate assembly establishments in Great Britain; but this consideration was of secondary importance when compared with the great necessity for economizing shipping. It may be mentioned in this connection that there were no mine assembly facilities in the United States, since all ammunition depots were congested with other work, and new assembly plants would have had to be created in any event, either at home or abroad.

It will be remembered that in the early stages of the consideration of the barrage, one of the proposals made was that Great Britain should furnish the men necessary to assemble the American mines. Accordingly, a board was appointed by the Admiralty on October 6, 1917, which has generally been referred to as the Lockhart-Leith Committee, to investigate and report on the various suitable localities for mine depots for this project. The report of the committee, dated October 26, discussed in detail the possible locations for such bases, reviewed the transportation facilities, and gave as their decision that the most suitable locations were the Dalmore Distillery, at Dalmore, Alness, and the Glen Albyn Distillery, at Inverness. The report went into considerable detail, outlining exactly what buildings would be required as well as the new construction and machinery, and estimated the personnel requirements. This report and its recommendations were approved by the Admiralty, and the distilleries at Dalmore and Glen Albyn were at once commandeered for use as mine bases.

Under date of October 26, 1917, the Bureau of Ordnance cabled Admiral Sims, informing him that the Bureau was preparing to manufacture mines in sufficient quantity for the operation contemplated, and that it was expected that the shipment of these mines would commence soon after the 1st of January, 1918. This cablegram

further stated that the Bureau desired to send Commander O. G. Murfin as its representative, under the Force Commander, to be placed in command of the mine depots which were to be established at Cromarty, also that several officers from the Bureau were being trained in the assembling and handling of mines and would be sent to assist him. This cablegram was followed by a letter from the Bureau of Ordnance, dated October 31, 1917, in which the subjects referred to in the cablegram were commented on at length.

On November 1, 1917, the Chief of Naval Operations cabled Admiral Sims to the effect that the Department concurred in the project of the mine barrier from Scotland to Norway, and was taking steps to outfit eight minelayers to sail about February 1, and that they were also expediting the completion of 12 minesweepers. This cablegram further stated that it was expected that the shipment of mines would begin about January 15, and that officers would be sent to confer and to arrange details within a few days.

The report of the Lockhart-Leith Committee was transmitted by the Admiralty to Admiral Sims, in London, who, in order to give the department early information relative to the selection and requirements of the two bases, sent the following cable on November 2:

Admiralty committee has investigated bases for northern mine barrage and Admiralty's full report on suggested organization of bases for assembling American mines. is being forwarded. Plan calls for United States base at Invergordon handling 2,000 mines per week and at Inverness handling 1,500. Combined personnel required from United States approximately 182 mechanics, 620 skilled laborers, 690 laborers, 40 clerks, and for dock working parties, 25 boatswains mates, 25 coxswains, 400 seamen and ordinary seamen. Most important that all these be enlisted men to insure military discipline and control and to avoid labor complications here. Commanding officers at depots should be rank of commander and each should have five or six other officers as assistants. Large distillery buildings will be taken over but there will be small amount of new construction required. Shops must be fitted up. Scarcity machinery, cranes, etc., in this country would make very welcome arrangement if United States could furnish some of these. At least one of officers sent for conference mentioned Opnav 925 should have had experience in manufacture mines in United States naval yards as Naval Constructor Knox has had. Some of depot staffs should come at same time as officers who return after conference so they will be in touch with work from beginning. Intended ship some mines by Lock Alsh and rail via Dingwall but ships for Kyle must not exceed 280 feet length nor 20 feet draft. Other mines will come via Fort William and by barge through Caledonian Canal. British Rear Admiral will be senior officer in general charge joint operations these and British bases in Firth of Forth. Admiralty desires verify immediately understanding that sinkers as well as mines will be furnished from United States. Furnish information concerning general character eight minelayers sailing February 1, and whether any other craft will be used for minelaying. Would also like to learn approximate number and kind of mine carriers. Will reply concerning *Old Colony* later. For localities mentioned see B. A. charts 115, 2182 B, 2167, 2635, 2676, 3547.

In reply to the questions contained in the above cablegram relative to the United States supplying enlisted men for assembling

the mines at the bases instead of employing British civilians, the Chief of Naval Operations cabled on 8 November that drafts of approximately 200 enlisted men per week would be sent over as soon as the bases were ready to receive them. Upon receipt of this information the Third Sea Lord wrote Admiral Sims as follows:

The Admiralty are most grateful and the decision of the Navy Department relieves us of very great anxiety * * *.

In accordance with the requests of the Admiralty and the desires of the Bureau of Ordnance that American officers who would be associated with the establishment of the bases and their operation should be sent to Great Britain as soon as possible, Commander O. G. Murfin, United States Navy, accompanied by Commander T. L. Johnson, United States Navy, sailed from the United States on 13 November, 1917. The Chief of Naval Operations cabled Admiral Sims on November 18:

Commander O. G. Murfin, under orders to proceed to England. Is authorized to speak for Bureau of Ordnance, discussing all details, depot arrangements, machine-shop equipment, unloading and transportation arrangements, with British Admiralty representatives, and make decisions in these matters. Commander Thomas Lee Johnson accompanies to assist Commander Murfin in plans and returns here with detailed information.

Commander Murfin and Commander Johnson arrived in London on November 23, 1917, and reported to the Commander, United States Naval Forces Operating in European Waters. The Force Commander issued orders to Commander Murfin assigning him to duty in charge of all matters relating to the establishment of United States naval mine depots in Great Britain and to duty in charge of such depots upon their establishment; he was further ordered to make his headquarters in London during the preliminary negotiations in connection with the bases.

On Novemoer 26, 1917, Commander Murfin and Commander Johnson left London to inspect the sites selected for the United States mine bases. They were accompanied by Capt. Lockhart-Leith, R. N., Engineer Capt. Gaisford, R. N., Mr. Heap from the Admiralty's controller's office, and Surg. Thompson, United States Navy, from the United States naval headquarters. The party arrived in Inverness on November 27, spent four days inspecting the base sites at Invergordon and Inverness, and the two shipping points at Kyle of Loch Alsh and Corpach, and then returned to London. Commander Johnson left England on December 6, 1917, for the United States.

At the time of this inspection, whisky was being removed from the distillery buildings preparatory to proceeding with the work of establishing the bases. At Dalmore ground had been broken for a branch railroad line to connect the distillery with the Highland Railway. Other work was being held up pending decisions to be made by Commander Murfin. These decisions having been given,

plans for expediting the work of establishing and outfitting the bases were proceeded with.

The Navy Department designated the base at Inverness as Base 18, and the one at Invergordon as Base 17.

The work of preparing and outfitting the mine bases was done by contract through the Admiralty. The construction work was done under the immediate supervision of the superintending civil engineer, Invergordon Dockyard; and the tools and equipment were supplied through the controller's department of the Admiralty. Rear Admiral Clinton-Baker, R. N., was the Admiralty's representative in general charge of the work, and desired alterations or additions to buildings or equipment were ordered on his approval. The construction was somewhat delayed, due to inclement weather conditions and to lack of suitable labor; but in spite of these handicaps good progress was made from the beginning. Commander Murfin kept in direct touch with the work by correspondence, by frequent visits to Rear Admiral Clinton-Baker's office at the Admiralty, and by frequent visits to the bases themselves.

Much of the material for these bases could not be procured in Great Britain because of the drain upon that country's supplies made by the war. At the Bureau the mine section secured the assistance of Capt. (then Commander) G. C. Schafer, Supply Corps, United States Navy, in connection with providing cranes and equipment of all kinds, assembly of material, and assuring delivery to the mine bases abroad, remaining in Washington until deliveries being assured, he proceeded overseas in March, 1918, and resumed this work at the mine bases, as a member of the staff of Rear Admiral Joseph Strauss, United States Navy, the commander of the operation of laying the barrage.

The first draft of men arrived in Liverpool on the S. S. *Philadelphia* on November 27, 1917. Lieut. Commander Edwin A. Wolleson, United States Navy, who arrived on the same vessel, was put in charge of the 37 rated men in this draft and sent with them to the British mine depot at Portsmouth for instruction at the mining school at that place. The remainder of the men in the draft were sent to Queenstown for distribution to the destroyer flotilla, owing to the fact that the bases were not yet ready to receive them.

On December 3 the second draft arrived at Liverpool on the S. S. *New York*. Twenty rated men from this draft were sent to Portsmouth to join the detachment there, and the nonrated men were sent to Queenstown to be held until accommodations could be provided at the mine bases. Lieut. Commander L. M. Stewart arrived in London and reported at headquarters on December 4, 1917, and was sent to Portsmouth to assist with the instruction of the men already there.

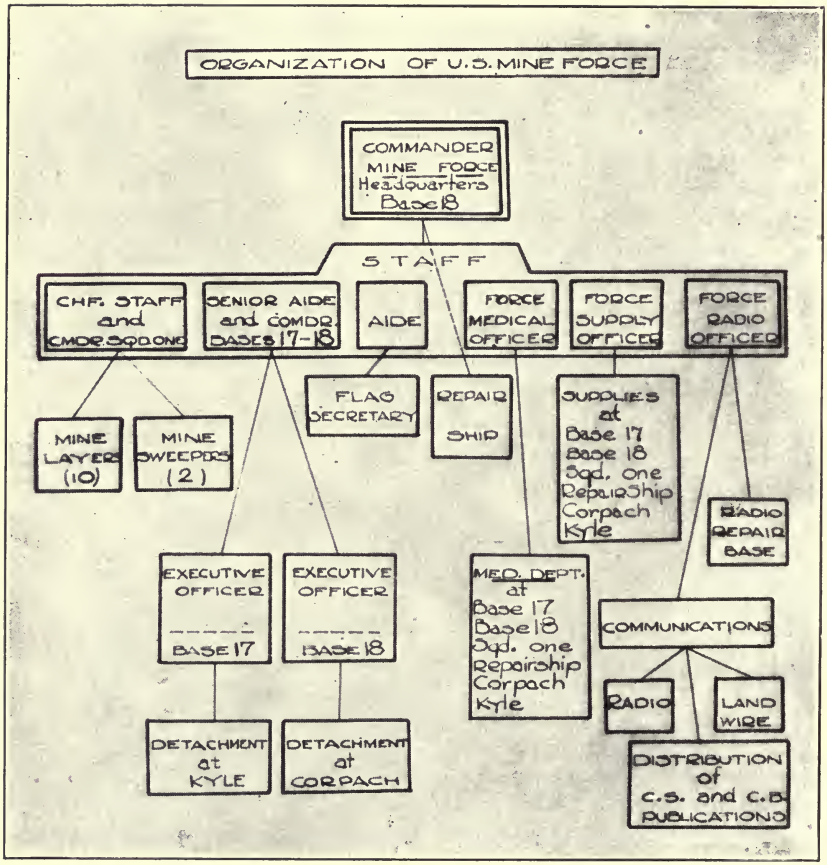
U. S. S. AROOSTOOK, MINELAYER, CAMOUFLAGED. (Page 75.)

U. S. S. BLACK HAWK, FLAGSHIP OF COMMANDER U. S. MINE FORCE, AND FORCE REPAIR SHIP, CAMOUFLAGED. INVERNESS, SCOTLAND.

(Page 85.)

U. S. MINELAYING FORCE, COMMANDER OF MINE SQUADRON 1 AND COMMANDING OFFICERS OF SHIPS. (Page 86.)

Front row, left to right: Capt. W. T. Cluverius, U. S. S. Shawmut; Capt. C. D. Stearns, U. S. S. Roanoke; Capt. R. R. Belknap, Commander Mine Squadron 1; Capt. H. V. Butler, U. S. S. San Francisco; Capt. A. W. Marshall, U. S. S. Baltimore. Back row, left to right: Comdr. B. L. Canaga, Aide to Commander Mine Squadron 1; Capt. T. L. Johnson, U. S. S. Canonicus; Capt. J. H. Tomb, U. S. S. Aroostook; Comdr. J. W. Greenslade, U. S. S. Housatonic; Comdr. S. Gannon, U. S. S. Saranac; Comdr. W. H. Reynolds, U. S. S. Canandaigua; and Comdr. D. P. Mannix, U. S. S. Quinnebaug.



PHOTOSTATIC CHART, SHOWING ORGANIZATION OF U. S. MINE FORCE.

(Page 88.)

Lieut. Thomas Newhall, U. S. N. R. F., reported at headquarters, in London, on December 10, and was assigned to duty as assistant to Commander Murfin. On December 26, Lieut. Newhall was sent to the bases as Commander Murfin's representative for keeping in touch with the construction work.

On January 7, 1918, Lieut. Commander Stewart with 23 men was sent to Base 18, and Lieut. Commander Wolleson with 22 men was sent to Base 17. These parties arrived at their destination on January 8. These small forces were assigned to the bases to assist in the arrangements for housing the personnel at the bases and to form the nucleus upon which the organization could be started. As the men's living quarters at the two bases were in an unfinished state, the men at Base 18 were quartered in the old Muirtown Hotel, which was one of the buildings taken over for base purposes and which was later made into the sick quarters. The men at Base 17 were quartered in the residence of the manager of the distillery, which was one of the buildings taken over in the grounds and was subsequently converted into the sick quarters at that place.

Commander Murfin left London January 25, 1918, and arrived at Inverness on January 26, taking direct charge of the work at the bases and establishing his headquarters at Base 18 and in the house which had formerly been the home of the manager of the Glen Albyn Distillery.

The United States national ensign was officially hoisted over the office at Base 18 on February 9, 1918, and at Base 17 on February 12. The raising of the flags at the two bases were made functions at which British civil and military officials, as well as the officers and men attached to the bases, were present and took part.

At the outset, the question of transportation appeared to be the greatest problem that would be encountered. The estimated weekly output of mines required for the minelayers was 3,500. The railroad from Kyle to Base 17 could only handle about 2,000 mines per week, and the Caledonian Canal running from Corpach to Base 18 could transport approximately 1,500 mines per week. This made it necessary to use two bases instead of one large base, for Inverness Harbor could not accommodate the full minelaying force, nor could the mines going through the Caledonian Canal readily be shipped to Invergordon. Although the bases were separated by a distance of 33 miles by rail and 25 miles by water, no difficulty was encountered in unifying the efforts of the two establishments and coordinating and directing the divided mine squadron anchored in the two harbors.

At Corpach mine carriers anchored in the stream opposite the entrance to the Caledonian Canal. Their cargoes were discharged into power lighters and dispatched to Base 18. The work of discharging

the cargoes of the carriers into the lighters was done by a detachment of 65 men from Base 18 permanently stationed at Corpach. The lighters, owned by the British, were manned by British ratings and their movements were directed by the British senior naval officer at Inverness. After the lighters arrived at the canal quay at Base 18 they were discharged by the United States forces at that base.

Vessels arriving at Kyle were taken alongside a small pier and their cargoes discharged directly into railroad cars, thence taken to Base 17 via Dingwall. The work of discharging the cargo into the railroad cars and shunting them across to the main line from the pier was done entirely by the 65 men from Base 17, who formed the detachment at Kyle. After being placed on the main line, the cars were delivered on the siding at Base 17, from where they were again handled by the United States personnel.

The first stores forwarded from the United States were sent via Liverpool, and were received at the bases January 20, 1918. The first mine carrier, U. S. S. *Ozama,* arrived at Kyle of Loch Alsh on February 18, with stores and equipment but no mining material. The second carrier arrived at Kyle on March 21, with general stores and equipment; the third was also routed to Kyle, arriving there April 3, with mine anchors and other mining material. The first mine carrier routed to Corpach arrived April 5, 1918, with mine anchors and other mining material. The first carriers containing mine spheres were the U. S. S. *Ozama,* which arrived at Corpach on May 21, and the U. S. S. *Lake Superior,* which arrived at Kyle on the 29th.

Officers and men reported for duty at the two mine bases from time to time until, on March 30, 1918, there were 18 officers and 414 enlisted men on duty at Base 17, and 23 officers and 359 men on duty at Base 18.

On March 1, 1918, both bases had reached such a state of completion that mines could have been received and assembly work could have commenced, although operations at this time would have been somewhat handicapped by the fact that a considerable part of the work at the bases was still in an unfinished condition.

By April 1, 1918, the main construction work was practically completed and the bases ready in every respect for the purpose for which they were established. Actual assembly work did not begin until May 29, 1918, the date upon which the first mines were received.

In general, the following work was done at Dalmore in establishing Base 17: The Dalmore Distillery was commandeered and taken over; some of the existing distillery buildings were refitted and made into barracks for the enlisted personnel, and others were refitted as storehouses for general stores and mine equipment; buildings were erected for workshops for mine assembly, for storage of mines and mine material, both in assembled units and in component parts; railroad

tracks were laid in the base from the main line of the Highland Railway and from the base to the pier at the dockyard, Invergordon; wagon roads were built connecting various buildings within the base; fire mains were laid, water systems provided; wash rooms, bathrooms, and other sanitary devices were installed; and commissary and messing facilities provided. An electric light and power plant was built, and other necessary equipment and adjuncts to a base of this nature were provided.

At Base 18 the same provisions were made as at Base 17, with the exception of the light and power plant—the lighting and power at Base 18 being received from the city plant.

At Kyle four huts were erected as barracks, mess hall, galley, and storage spaces for the men of the detachment at that place.

At Corpach a large private residence was taken over and converted for use as barracks, mess hall, galley, and storehouse for that detachment.

After unloading the mine parts from the railroad cars at Base 17 or the lighters at Base 18, the various parts were sorted and placed in bulk store. These stores were, in general, adjacent to the assembly sheds, so that miscellaneous parts could be readily supplied as required.

The work of assembling the mines was a highly organized process developed in accordance with the present standards of manufacturing efficiency, wherein each man performs one specific task over and over again as the mines are moved along in front of him for the various stages of assembly.

As soon as the commanding officer of the bases was informed of the quantities and types of mines which would be required at each base for the minelayers, the work of assembly began. The various component parts for the mines began to pour into the assembly sheds from the bulk storage rooms. The two principal parts constituting the mine were the anchor and the mine sphere. As the anchors arrived they were placed upon assembly tracks extending across each bay. Along these tracks were stationed groups of men, each group making some special adjustment, testing the brake tension, release mechanism, etc., as the anchor was rolled along the track. By the time the anchor reached the end of the track the mine case, which had at the same time undergone preparation and testing while moving along a traveling table, was completed and the two parts were ready to be married to each other. This done, a few final adjustments were made, and the mine was ready to be placed on board a minelayer. From here the completed mines were either rolled into ready-issue sheds directly opposite the assembly bays or else were loaded directly into railroad cars to be sent to the ships.

From the railroad cars the assembled mines were carried back to the canal siding at Base 18 or to the dockyard at Base 17, where they were loaded into barges. The barges carried from 50 to 60 assembled mines, and were towed out to the ships and placed alongside while the ship's crew whipped the mines aboard and stowed them on the tracks ready for laying.

The original estimates prepared by the British as to the rate of transportation from Kyle to Base 17 and from Corpach to Base 18 were far below that actually accomplished. The rate of assembly and the possible rate of laying mines also much exceeded the original expectations. Therefore, the rate originally fixed for shipping 3,500 mines per week from the United States was increased to 6,000 per week. In spite of the greatly increased amount of work in assembly which developed on account of defects discovered in the actual mining, the rate of assembly at the two bases was increased from the original estimate of 500 mines per day to as high as 1,340 mines per day. Similarly, the time required for the minelayers to refuel, take on water, embark mines and necessary supplies had been so systematized that only two days in port were necessary before they were ready for the next excursion. This made it possible to carry out excursions every four or five days, depending upon the distance it was necessary for the vessels to proceed in order to lay their mines. As will be seen, delays almost heartbreaking occurred which kept the squadron in port from two to three weeks between excursions. While none of these delays could be foreseen, the mines from the United States continued to arrive until the storage facilities were most severely taxed. The original plan of the bases called for a total storage of 12,000 mines at both places. At one time as many as 20,500 had accumulated. Wise foresight, however, on the part of the commanding officer of the bases had made it possible to stow them all under cover, protected from the incessant rain of northern Scotland.

The headquarters of Rear Admiral Joseph Strauss, Commander Mine Force, and of Capt. Murfin were at Base 18. The two mine bases were so organized that there were two executive officers, representatives of the commanding officer, in complete charge of all administrative and industrial activities at their respective bases. Each base was organized with military, industrial, supply, medical, and transportation departments.

The industrial officer was responsible for the assembly of mines, which work was organized along lines similar to those obtaining in automobile plants in the United States. The various component parts of the mines were received and stored and inspected preliminary to assembly separately. In the assembly process, the two major

parts, the mine case and the anchor, moved along on small trucks on rails, the various minor parts being assembled progressively, to a point where the mine and anchor were "married" together, and thence placed in the "ready-for-issue" sheds or loaded into cars for delivery to the mine layers. This system, under which separate groups of men, highly specialized, performed the same function for each mine or mine anchor, proved most efficient, and produced results never before attained in the rapid handling of mines.

Admiral Mayo, commander in chief, Atlantic Fleet, inspected the bases September 25–27 and October 5–7, 1918, and reported most favorably on their condition. Quoting from his report:

> The personnel throughout, both commissioned and enlisted, appeared to be satisfactory as to number and selection; their military appearance, bearing, and uniform made a favorable impression. The men are granted liberty freely and their relations with the natives of the towns and surrounding country appeared to be excellent.

Quoting further:

> Owing to the relatively late start of the operations, it has been necessary for the entire force, ashore and afloat, to work at high pressure in order to complete the original and later plans before bad weather sets in. The response of the personnel has been excellent and is considered indicative of a highly satisfactory state of morale.

Admiral Mayo concluded his report with the remarks:

> (*a*) The arrangements in force are remarkable for their conformity to the plans prepared at home before the mine force crossed the Atlantic.
>
> (*b*) The inspection of the mine force and bases and of the activities in connection with the work incident to minelaying in the North Sea, revealed a highly satisfactory condition and reflects great credit on the Commander Mine Force and on his assistants.

Chapter XI.

ORGANIZATION OF MINE SQUADRON AND SELECTION OF NEW MINELAYERS.

Prior to the decision to proceed with the northern barrage project, the mine force of the United States Navy included only two minelayers fit for the project, the *San Francisco* and *Baltimore*. This force possessed very small minelaying capacity, and it became necessary, as one of the first steps in preparation for the project, to greatly enlarge the force by taking over a sufficient number of merchant ships and converting them into minelayers, to obtain and train the officers and crews for these vessels, and to secure the requisite merchant tonnage for transporting the mines and other material to Europe.

On the basis of an estimated output of 5,000 mines a week and of one minelaying operation a week, the department concluded that the mine force should have a capacity of at least 5,000 mines ready to lay, which, if all went well, would insure the laying of the northern barrage in three months.

The *San Francisco* and *Baltimore* had a combined capacity of only 350 mines. It was necessary, therefore, to create practically a complete new mine squadron to secure the requisite capacity. Vessels were desired of ample size, yet handy in tactical formation; serviceable condition as to engines, boilers, pumps, etc.; good cargo-handling equipment adaptable for handling mines; internal arrangement suitable for installation of mine tracks on two or three decks; speed of 14 to 20 knots; and generally seaworthy. From data on file in the Navy Department it was found that four vessels of the Morgan Line, running between New York, New Orleans, and Galveston, were generally satisfactory for the purpose. They had been built by the Newport News Shipbuilding Co. to replace vessels of the *Prairie* class, purchased by the United States Navy in the Spanish-American War, and were in good condition. They were 391 feet long, 48 feet beam, and 20 feet draft when loaded as minelayers. They were capable of a sustained sea speed of 14.5 knots and had ample bunker capacity. Their capacity was estimated at 800 to 850 mines each.

The Secretary of the Navy personally informed Mr. Hurley, president of the Shipping Board, about the projected barrage operation;

and the department's request for the four Morgan liners was promptly granted, notwithstanding the prevailing dearth of shipping and despite the fast mounting demands for tonnage. The vessels were delivered to the Navy as soon as they had discharged the cargoes then on board or loading. The first taken over, the steamship *El Dia*, renamed *Roanoke*, was delivered November 16, 1917, at Tietjan & Lang's shipyard, Hoboken, N. J., where the work of conversion into a mine planter was promptly undertaken. *El Rio*, renamed *Housatonic*, followed at the same yard November 25; and *El Siglo* and *El Cid*, becoming the *Canandaigua* and *Cononicus*, respectively, arrived at the Morse shipyard, South Brooklyn, November 22 and 24.

Some high-speed vessels were desired for the mine force, but there were few such vessels under the American flag. On the Atlantic coast there were only three of suitable size and build, one of which, the *Old Colony*, had been promised to the British Navy. The others were the *Massachusetts* and *Bunker Hill*. These last two were taken over by the Navy, were renamed the *Shawmut* and *Aroostook*, and were delivered at the navy yard, Boston, November 6 and 10, for conversion. These vessels could each carry about 300 mines on one deck. They had a speed of 20 knots, but a very short steaming radius, about 2,300 miles at economical speed.

Two more vessels, the *Jefferson* and *Hamilton*, of the Old Dominion Line, plying between New York and Norfolk, were requisitioned by the Navy and taken over December 2 and 6, 1917. They were renamed the *Quinnebaug* and *Saranac*, respectively, and the work of conversion was undertaken at Robbins repair yard, Erie Basin, and James Shewan & Sons' repair yard, both in South Brooklyn. Their speed was about 16.5 to 17 knots and their capacity 600 mines each, carried on two decks.

Thus a total of eight vessels was acquired for conversion into minelayers, which, with the *San Francisco* and *Baltimore*, formed a squadron of 10, with a total capacity of about 5,500 mines.

The conversion of the Morgan minelayers (*Roanoke*, *Housatonic*, *Canonicus*, and *Canandaigua*) was an undertaking of extensive detail. It involved enlarging the forward orlop deck; making a reserve bunker in the hold forward of the boiler room, to replace the existing upper bunkers which were cleared off the third deck; making a separate compartment in the hold for the elevator pumps, and rearranging smaller compartments for the dynamo room and machine shops; closing the cargo ports and providing chutes for coaling over all with mines on board; cutting stern ports for launching the mines through, and raising the rudder quadrant to give the needed clearance; repairing (largely renewing) and resheathing the second and third decks; enlarging the officers' quarters to accommodate the more numerous naval complement; providing commissary, messing, and berthing

arrangements for a crew of about 400, including bakery, scullery, and a naval galley—no easy matter with the large amount of interior space to be reserved for the mines; building storerooms, magazines, water tanks for storage and distribution, washrooms, and closets, installing a fire system and magazine sprinklers; replacing the anchor engine and windlass with one of more power to handle larger chain and heavier anchors, stowing on billboards; on deck, building gun platforms forward and aft, lookout stations, and navigating and signal bridges, together with speaking tubes and accessory apparatus for fire control and other communications; making and altering hatchways for crews' use and for mine handling; altering boat stowage and davits for heavier boats; and installing davits and booms for embarking mines. Watertight subdivision far below the ordinary naval standard had to be accepted, on account of the limited time available; but some improvement was effected by making existing bulkheads stronger and, with their openings, watertight where possible, and by building two new bulkheads, one forward and one aft, to divide the largest compartments, so that the ships would have a chance of keeping afloat, if only one compartment were flooded.

On the main machinery, the work to be done was chiefly overhaul and repair; but to the auxiliary machinery much had to be added. The electric plant was more than doubled. An evaporator and distiller for fresh water, special hydraulic pump installation for the mine elevators, refrigerating machinery, a larger radio telegraphy plant, a considerable number of additional winches for embarking and handling the mines, a steam heating system, and a machine shop were all new.

The provision of adequate ventilation was a problem. In these cargo ships it was entirely lacking where the crew were to be. In the region where the ships were to operate, keeping the large hatches constantly open for airing out below decks could not be counted upon. In the crowded conditions that would obtain when the ships were at sea with mines on board, considerable supply of fresh air and exhaust for the foul was very important to ordinary comfort, as well as for the prevention of possible spread of respiratory infection. The principal difficulty encountered was to obtain ventilating blowers in number and capacity to meet the minimum requirements. In this respect the conversion of these ships was least satisfactory.

The two Old Dominion liners (*Saranac* and *Quinnebaug*) required somewhat different treatment in conversion. Their state of preservation was comparatively poor, and their original construction, in general and in details, much inferior to that of the other ships taken, A considerable part of the light upper passenger decks had to be removed, the parts retained strengthened by extra side plating and interior stiffening. Their general arrangement as minelayers, how-

ever, differed from that of the Morgan liners only in details and in their carrying mines on two decks only, instead of three, with correspondingly fewer elevators. The extra space above the main deck made better provision possible for officers and chief petty officers, with consequently more room for the men below, and gave better ventilation generally; but the additional height above water was otherwise of no advantage. The single, low mast, which was all they had at first, was afterwards lengthened by a topmast, to give the necessary hoist for signals and radio.

In common with all other ship alterations in hand at the time, the original plans had to be based on what could be done within a reasonable time with material and labor scarce. There was no available data for mining installations on the scale we had undertaken. Some British mining memoranda were received, and later a few blue prints from some of their plans. Also Lieut. De Salis, R. N., placed all his experience at our disposal. But as other nations had not made a success of mine elevators or gone in for mine-carrying capacity to the same extent we had, little of their data proved applicable. The experience of the *San Francisco* and *Baltimore* during the past two years, however, was invaluable, enabling the decision of many questions of detail, both before and during the conversion, to be made with confidence that subsequent results confirmed as well founded.

The plan finally arrived at for the mining installation of the new ships consisted of two tracks for mines on each side of the second or launching decks, extending about three-fourths the length of that deck. On the deck below there were likewise four long tracks; and inboard, aft, four or more short stowage tracks. In addition to these, the four large minelayers—*Roanoke, Housatonic, Canonicus,* and *Canandaigua*—each had stowage tracks on the enlarged forward orlop deck. Cross tracks and turntables connected all tracks at points sufficiently distributed to insure against a breakdown at any point cutting off the mines beyond. Mines were transferred from the lower stowage decks to the launching deck by elevators. This was a unique and typically American feature of these vessels. Elevators had been abandoned by other nations as impracticable. After considering various possible methods of transferring mines from the lower decks to the upper decks so as to permit the whole cargo of mines to be launched in one continuous string, the elevators were chosen in preference to launching from two decks, or to installing inclined planes, conveyor machinery, or ordinary whips and trolleys. Rather than attempt to design a new elevator, the representatives of the Otis Elevator Co. were called in at the outset and informed of the requirements. These representatives stated that they would meet the necessary requirements, which was more than borne out in the actual installation. The elevators were of

two types, electrical and hydraulic, with automatic stop and leveling devices, capable of carrying two mines and designed to make a round trip in one minute, including the time of loading and unloading the car. This rate was eventually doubled in use.

On the four large layers there was only room for one launching port on each side of the deck. It was therefore necessary to install a switch so that the mines on the two tracks on each side could be planted from their respective ports without using a turntable. This was also a novel feature which had been abandoned more or less as impracticable by the British, but which gave most excellent service as installed. On the other four new mine planters there was sufficient room aft to cut four launching ports, one for each track, thus eliminating the necessity of switches. The *San Francisco* and *Baltimore* had but one port each, and due to the limited space, it was impossible to install another. All ports were closed by a substantial water-tight door, the section of track in its wake being hinged back when the door was closed.

In the process of planting, the mines on the lower decks were brought forward to the elevators; hoisted to the launching deck; then hauled aft to the launching trap after those originally stowed on the launching deck had been planted. To haul the mines along the tracks, they were made up in "fleets" of 30 to 40 mines, and moved by means of a wire rope rove around a "bogie" attached to the end of the last mine anchor and thence led to a winch. To keep the mines moving at the necessary speed on all sections of the track required an installation of as many as 13 winches on the largest minelayers. As the mines arrived near the launching trap, the "bogies" were disconnected and the mines were run aft into the trap by hand. The trap consisted of a simple lever device, designed to release one mine at a time, allowing it to roll overboard along the slanting section of the track extending through the launching port.

The mines were embarked from the upper decks, using the regular cargo booms or davits specially placed for the purpose. Small hatches were cut for embarking the mines so they could be struck down one, two, or three decks, and landed on tracks from which they could be run to their stowage positions. By this method it was possible to embark mines simultaneously at four points with such speed as to load even the largest layers in less than five hours.

Shortly after the ships had been taken over and sent to the various shipbuilding yards for conversion, the commanding officers and executive officers were ordered to their ships to hasten the work by keeping in constant touch with the various items on which least progress was being made. About Christmas the *San Francisco* and the *Baltimore* were sent to the navy yard at New York for their final outfitting before sailing for Europe.

The *Shawmut* and *Aroostook* having been constructed mainly for navigation between Boston and New York by the inside route, there was doubt of their structural strength for the open seas. Thorough examination showed that their steel hulls, though of shallow depth, were well built, requiring no underwater strengthening, and that by doubling the main deck stringers and sheer strakes, running a light plate deck and stiffening the structure above the main deck, in order to secure longitudinal stiffness, they could be made thoroughly seaworthy. These ships, of 4,500 tons displacement, 375 feet long, 52 feet beam, 18 feet extreme draught, were twin screw, oil-burning, of 20 knots speed with possibilities under naval management and good fuel of making 21 or more. They could readily be given a fuel capacity of 4,000 miles at 10 knots and 1,000 miles at 20 knots. Through unremitting efforts, in view of the tactical value of these ships as a fast wing in general mining operations or for "repairing fences" after such operations, they were taken over November 6 and 10, purchased outright, and their alteration begun. The objection to the inclusion of these ships in the force was directed against their seagoing qualities and the extent of the work required to convert them. This conversion meant stripping them down to the main deck and rebuilding upward from that point, for, as passenger ships, their entire upper structure was of wood.

The *Shawmut* and *Aroostook* were placed in commission at Boston Navy Yard, 7 December, 1917, and the assembling and organizing of their crews proceeded concurrently with their conversion. Upon removal of the superstructures, the crews were scattered to available spaces in yard shops, and subsisted temporarily on various ships. This continued during a most severe winter with the thermometer many degrees below zero while the work was in progress. The men were finally transferred to temporary quarters on a hospital barge moored near by. The ships' officers were established in a part of the removed superstructure landed on the dock alongside. This included the pilot houses, in which the officer of the deck was located. The captains organized their crews in industrial gangs for structural work, as well as for their duties in the ships. These gangs were made up chiefly of members of the crews who had had previous experience in the industrial trades of riveters, calkers, ship fitters, carpenters, and were placed in charge of officers who had a knowledge of structural steel working. They conformed strictly to yard hours, including overtime—a normal condition—except that for their overtime hours, the enlisted men received no additional pay.

Both ships were completed the same day, June 10, 1918, and in all respects so thoroughly that only six days later they sailed for Scotland.

Chapter XII.

TRAINING THE PERSONNEL AND COMMISSIONING THE SHIPS OF MINE SQUADRON ONE.

The sudden expansion of the mine force from 2 mine layers to 10 entailed a proportionate expansion of mining personnel, which offered considerable difficulty. In comparison with the projected northern barrage operation, the United States Navy had had very little experience in mining, and this experience was confined to a very few officers and men. It was partly for this reason that the Bureau of Ordnance designed the Mark VI mine in such a manner that it could be handled on board ship practically as "fixed ammunition," so that a minimum of experience and training of the ships' crews would be necessary to its successful use.

The officers and crews of the *San Francisco* and *Baltimore*, together with selected officers and men who had had previous experience in our small mine force, afforded a nucleus around which to build up and with which to train the new force, and this last most important work was promptly taken up.

In October, 1917, when the northern barrage plan assumed definite form, the *Dubuque*, which had belonged to the force but which was too small to be of much use in extensive mining operations, was in use as a training ship at Annapolis; and the tugs were temporarily attached to the train, Atlantic Fleet, leaving only the *San Francisco* and *Baltimore* for work in connection with preparations for the barrage operation.

On the request of the Bureau of Ordnance, the *Baltimore* was detailed to carry out certain practical experiments involved in the evolution of design of the Mark VI mine. Thus the *San Francisco* was the only vessel wholly available for the training of men for the crews of the new mine planters.

One of the first measures taken to train the new personnel was the establishment by the Bureau of Navigation of a mine force training camp at Cloyne Field Barracks, Newport, R. I., a part of the cantonments provided for the second district Naval Reserves. Accommodations were provided here for 1,050 men, who were subsisted and carried for pay locally but were under the Commander Mine Force in other respects. This camp was established on November 11.

The officers who were detailed to conduct the training at this camp had had duty in mine ships. The men for each of the new ships were

grouped under officers of their respective ships. As the ships went into commission their crews were withdrawn from the training camp. Capt. Belknap, in his History of Mine Squadron 1, gives the following account of the training of the crews and the commissioning of the new ships:

The training was general, including seamanship, mines, gunnery, signals, infantry, and boats. For five weeks the *San Francisco* and *Baltimore* were present, giving practical instruction and experience in mine handling. A part of their regular crews were transferred to the barracks and replaced by new men. These would be on board for a week or 10 days, then another lot would come. There was not time to cover all men in this fashion, but it was expected the information picked up would spread. During the summer of 1917 a detail of 150 reserves, later increased to 400, had been sent from Newport to New London, Conn., to work with the mine force on antisubmarine net making and planting. The work being completed, a considerable number of the first 150 were obtained for the new mine ships. Along with the net making, they had been given a regular and systematic training by the *Dubuque's* officers, which was now to prove of direct benefit in the mine force. During this training-camp period at Newport, the weather was at times biting cold, but the results were well worth while. The *Sonoma* and *Ontario* helped at this time in practical seamanship, signals, and quartermaster training, until withdrawn to assist the Shipping Board to get vessels out of the St. Lawrence River ice. The *Patapsco* and *Patuxent* carried on the same work after completing repairs, about February 1 and March 1, 1918.

For radio instruction a class was established in mid November on board the *San Francisco*, consisting of likely material from the training camp. When the *San Francisco* went to Shewan's yard, December 18, 1918, her radio force was largely augmented by the best men from this class and instructions were continued during her overhaul. This included visits to shops and to the radio laboratory at the navy yard, Brooklyn. The remainder of the original class continued instruction under one of their own number at the training barracks. When the *San Francisco* was about to leave Shewan's yard early in March, her excess radio men were distributed among ships fitting out in New York, to assist with the installation of their equipment and become familiar with it. Later, when this squadron assembled, training in British procedure was taken up, enabling the squadron radio force to adopt it within a day after arriving in Scotland.

For instruction in signals, especially British, flags and procedure, a class was formed at Newport, January 29, to which signal quartermasters and signalmen from all ships were sent for about a month's training. To these, 50 more were added from the signal class at the Newport Training Station. All were divided into groups by ships and given an intensive course in all kinds of signaling and quartermaster duty. Capt. E. H. Campbell, commanding the Newport Training Station, placed all desired facilities at the disposal of the force, and for practice afloat first the *Patapsco* and then the *Patuxent* also were available. The value of this preliminary instruction was later demonstrated by the excellence of the signaling during the mining operations. Great credit is due to the leading chief quartermaster, William H. Kerens, of the *San Francisco*, and the other chiefs, for the quick and accurate communication by signals which they made possible.

The importance of a well organized and trained lookout service was early given attention, resulting in an excellent arrangement of stations, communications, and procedure.

For various reasons the full number of 1,050 for which training-camp accommodation had been provided was at no one time complete, but the training was supplemented elsewhere, so that few, if any, wholly untrained men were received by any ship. As soon as she was ready for them three gun crews trained in the battleship force were

drafted to each ship. Similarly, the engineer department personnel were assembled at Philadelphia and kept under training until wanted. The quotas of experienced petty officers, artificers, and lower ratings began to be assembled on board the receiving ship at New York in January, but the constant demands from other quarters interfered much here. Permanent association of men with ships on a satisfactory basis hardly began much before the ships went into commission.

For the officers, similar measures were taken to put them in touch with the methods and the results of experience in the mine force. A conference of all new commanding officers and executives with Capt. Belknap and Commander Butler was held on board the *San Francisco* in Newport on December 3, at which the operation in hand was described, along with the doctrine and other matters peculiar to the force and to the particular service of the ships. The mine force training instructions were reprinted and issued. Matters pertaining to training and organization were taken up at the subsequent conferences held at New York and Boston through the winter, and although the ships were as yet neither assigned to the mine force nor in commission, the acting Commander Mine Force, Capt. Butler, sent them for guidance copies of all letters and instructions likely to be of useful information. In addition, the mining officers were given practical instruction on board the *San Francisco* and *Baltimore* in late November and during the mine experiments conducted by the *San Francisco* in the spring in Chesapeake Bay, at Newport, and off Cape Ann.

The association of the new ships' officers at New York with one another and with those of the *San Francisco* and *Baltimore* during January and February made for good progress in working out the organization and future procedure on board the new ships during minelaying. Study of the blue-print plans made the officers fairly familiar with the ships' installations, so that by the time they moved aboard and began actual drills and tryouts much of the preliminary work had already been done. To facilitate the early establishment of routine on a regular basis, so that time might sooner become available for specialty training, the *North Dakota's* routine book was revised so as to be suitable for the new minelayers, its adoption in whole or part, however, being optional with each commanding officer.

The first ships to be commissioned were the *Shawmut*, Capt. W. T. Cluverius, and *Aroostook*, Commander J. H. Tomb, at Boston, December 7, 1917. Their crews had been built up and organized comparatively early, their own labor considerably hastening the completion of the ships, as told elsewhere. The popularity of their prospective service was a great stimulus. Many applicants of all ratings from ships visiting the Boston yard, keen to go across on the minelaying expedition, volunteered to the captains of these two ships.

Next to commission were *Roanoke*, Capt. C. D. Stearns, and *Housatonic*, Commander J. W. Greenslade, on the 25th of January, 1918. Conditions in the neighborhood of their shipyard and on board the ships made an earlier date impossible without retarding their conversion. Living conditions were extremely rough amid the dirt and disorder, made worse by the slush and mud in the unpaved shipyards; but the presence of officers and men on board exerted constant forward pressure on the work, while they at the same time were becoming acquainted with the details of their ships. At the Morse yard conditions were not favorable for commissioning until March 2. The decision of the appropriate time for commissioning was left to the respective commanding officers, who, watching the work's progress from day to day, were in the best position to choose. The *Canandaigua*, Commander W. H. Reynolds, and *Canonicus*, Commander T. L. Johnson, commissioned March 2, the *Quinnebaug*, Commander D. P. Mannix, not until March 23, but most of her crew had been assembled, organized, and accustomed to the ship from a much earlier date. Last to commission was the *Saranac* Commander Sinclair Gannon, April 9, 1918.

Chapter XIII.

COMPLETION AND SAILING OF MINE SQUADRON.

The date of departure of the mine squadron had been fixed tentatively at February 1, 1918, partly because it was believed originally that this program could be met if all went well and partly because it was feared that other work no more important might be given precedence. It was soon found, however, that the date for completion would have to be postponed because of unavoidable delays, and consequently February 24, March 15, and March 21 were successively worked for.

Throughout December to March, crowding in the shipyards, scarcity of material, congested transportation, shortage of fuel, and severe weather, made a combination of difficulties especially unfavorable for outside work on the minelayers, of which there was a good deal to be done. By constant urging, anticipating probable causes of delay, and persistently following up behindhand deliveries, the work as a whole was kept always progressing, if at times slowly. Work on the Morgan liners was undoubtedly helped by having them in pairs at two ship yards, a good arrangement for mutual assistance and emulation; and, as the time for completion drew near, some spirit of competition was aroused between the managers of the two yards. Of the other two ships at New York, which were placed singly, the *Saranac* at Shewan's yard was greatly delayed, by some apparent disaffection among the shipyard employees, and by partial strikes. Special measures had at last to be taken in her case, finally getting her to sea six weeks behind her sister, the *Quinnebaug*.

A great deal of the delay was undoubtedly due to lack of interest on the part of workmen. The subsequently successful campaign of addresses to the workmen by good speakers, explaining the need for the ships and the men's own interest in doing their best, did not begin until sometime in February and then only in a small way. Another serious retarding cause, constantly present, was insufficient supervision of the work. The contractors were new to Government work, the vessels were of a type for which no model existed, and plans were not forthcoming as fast as wanted, nor often in the logical order. Several delays or losses of material in transportation held up other work and one of the trades—shipfitter—in which labor was shortest was the one on the completion of whose work much of the other work was dependent. Finally, by the end of the first week in

April, five ships had been sufficiently completed to leave the shipyards and go to sea. Yet these ships, which with the *San Francisco* and *Baltimore* represented three-fourths of the total mining capacity, late as they were, were not behind the time the mines were ready, the manufacture of these likewise having suffered from the prevailing unfavorable industrial conditions.

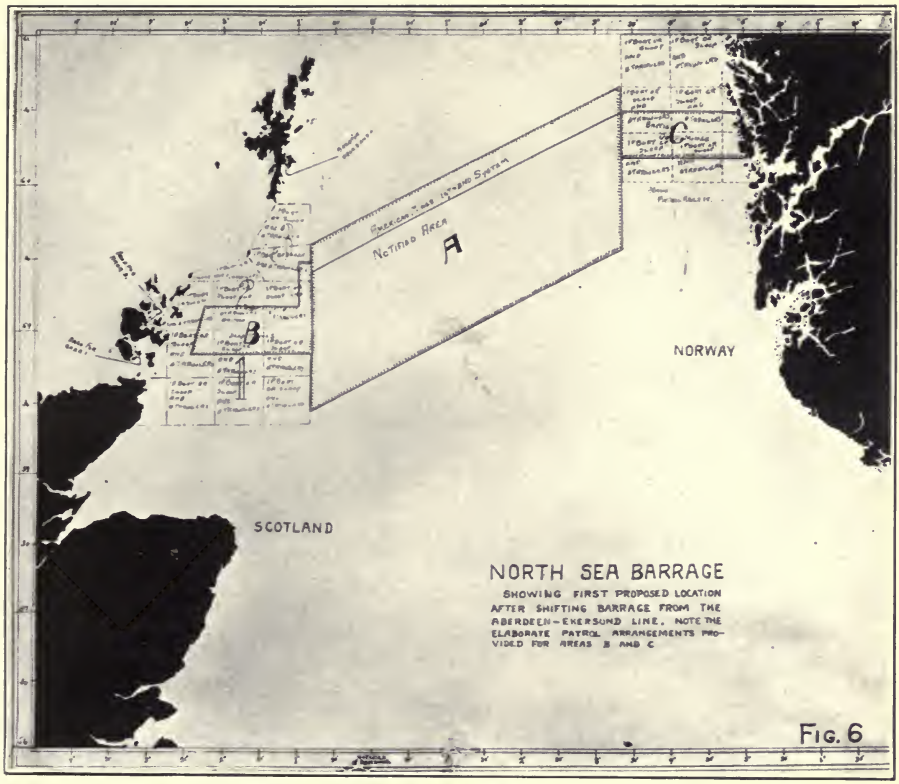
First away from the shipyard, 4 April, 1918, was *Roanoke*. She had been the first of the Morgan liners taken over, but to get her away even then it was necessary to take her to the Brooklyn Navy Yard for a few days, to concentrate on her electric wiring. Several items were incomplete, but a break had to be made away from the shipyards, and it did not become necessary to send her back. The *Housatonic* followed close afterwards, 6 April, similarly incomplete; then *Canandaigua*, 8 April. The latter had a long list of unfinished or poorly finished items, including the ice machine and partial installation of the ventilation system. *Quinnebaug* and *Canonicus*, on 14 and 16 April, respectively, made a total of five ships ready about the same time. Among these, the shortest time under alteration, was 4 months and 12 days; the longest, 4 months and 24 days.

A tentative schedule prepared by the British Admiralty in the early part of December, 1917, named May 1 for the completion of one system of the mine barrage, allowing one month to do the mine laying. Subsequent events made that date impossible to meet, in spite of all efforts; but the ships' officers were doing all they could to advance their preparations for active service without retarding the work of the shipyards, so that when the vessels did leave, they should be coaled and stored as completely as the state of the supply market permitted. A memorandum had been issued to them on 28 February, outlining the tentative employment of time prior to going across, as follows:

(*a*) On leaving the yard, each ship was to drop down to Gravesend Bay to receive 50 Mark IV mines to be used for training; these to be turned in before departure for abroad.

(*b*) Each ship was to proceed to sea independently for one week, for a shakedown, general clean-up, and preliminary ship drills, finishing the cruise at Hampton Roads. At discretion, ships were to go into Chesapeake Bay for part of the time, keeping clear of the rest of the fleet.

(*c*) One week was to be devoted mainly to training in mining, first taking half of the ship's capacity on board, for working out the handling of winches, parbuckles, fleets, elevators, and crossovers. During the following week, enough more mines were to be taken to fill to capacity, less one track load on each side of the launching deck. This was afterwards changed to leave one deck clear of mines, to make room for extra men carried to fill the mine bases. At the end



PHOTOSTATIC CHART, NORTH SEA BARRAGE.

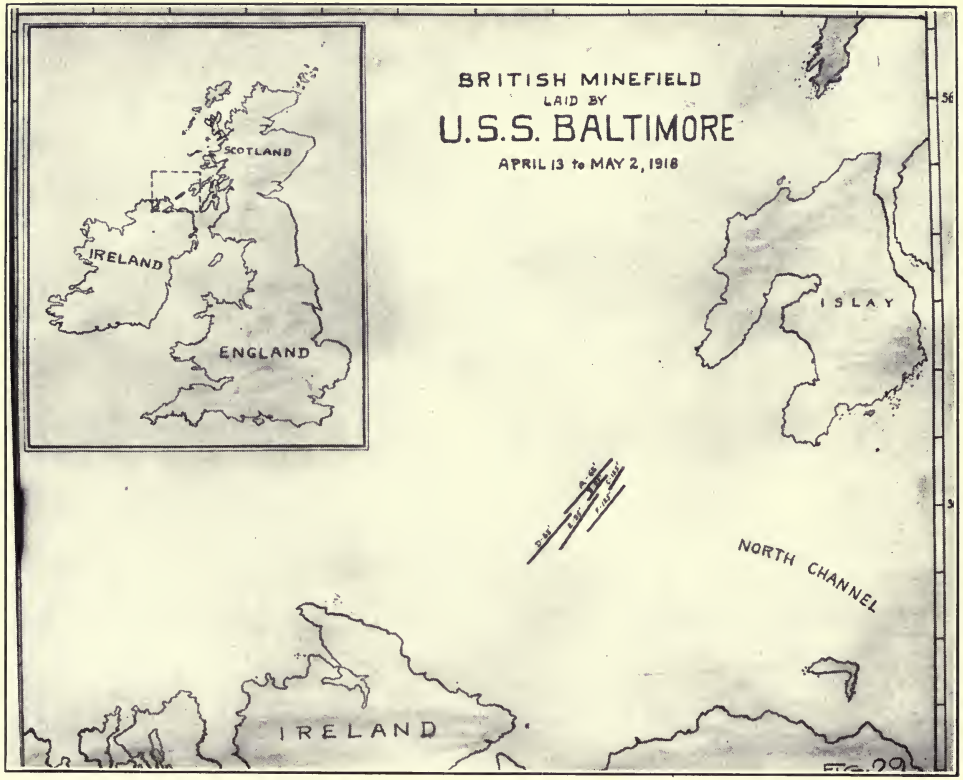
Showing first proposed location after shifting barrage from Aberdeen-Ekersund line.

(Page 92.)

(Page 102.) U. S. S. BALTIMORE OF MINE SQUADRON 1, NORTH ATLANTIC FLEET.

BRINGING MINE LIGHTERS ALONGSIDE THE U. S. S. SAN FRANCISCO OF MINE SQUADRON 1, NORTH ATLANTIC FLEET, INVERNESS FIRTH.

(Page 104.)



PHOTOSTATIC CHART, SHOWING BRITISH MINE FIELD LAID BY U. S. S. BALTIMORE, APRIL 13 TO MAY 2, 1918.

(Page 103.)

of two weeks, two to four days were to be spent in coaling, completing with stores, and other final preparations.

(*d*) On the passage across there were to be tactical and gunnery exercises and ample opportunity for moving mines about as desired for training on board.

The final aim was to arrive at destination ready, after loading with mines and coal, to begin planting. It was estimated that 45 days after leaving the shipyard would suffice for the competion of this whole program. The squadron was, therefore, working without a definite date but within a definite lapse of time. Its arrival at the mine bases in Scotland, during the night of 25–26 May, was on the fortieth day from the time the last ship left the shipyard. On arrival all were ready, requiring only coal and mines.

Having completed her final fitting out and conducted successful experiments with the new mine in Chesapeake Bay, March 13–15, in Narragansett Bay, March 20–21, and off Cape Ann, April 1–5, the *San Francisco* returned to Hampton Roads; and there, on Wednesday, April 10, 1918, Capt. R. R. Belknap, having been detached from the Office of Naval Operations, assumed command of the Mine Squadron, with additional duty as chief of staff to the Commander Mine Force, Rear Admiral Joseph Strauss, who had already proceeded to the mine force headquarters at Base 18, Inverness, Scotland.

On April 12, 1918, the first of the new minelayers, the *Roanoke,* stood into the Roads, followed the same day by the *Housatonic,* and the next day by the *Canandaigua.* Immediately upon arrival, these vessels proceeded to take their complement of mines from the mine carrier Lake Superior and from Southern Railroad Pier No. 4 at Pinners Point.

So far all had gone smoothly; but early Monday morning, the 15th, the *Housatonic,* in getting underway from Pier 4, broke the side of her hot well casing, completely disabling the main engine beyond repair in less than 10 days. The work was taken in hand immediately by a force from the Norfolk Navy Yard, and at noon Tuesday she was towed to the yard, where every effort was made toward early completion. There was no choice but to wait and take advantage of the time in completing and improving such work as had not been done to satisfaction at the ship yards. In this respect, the enforced delay was a benefit, as some navy yard help was given other ships, too, which relieved the small repair gangs of the ships from a discouraging amount of pressing work, hopeless of accomplishment unaided.

It became evident by Thursday, the 18th, that the unfinished items on board *Canandaigua,* which was the worst of any vessel in this respect, could not be completed without navy yard help by the time the *Housatonic* would be ready. The commandant at the Norfolk

yard was applied to that night by radio, and he and the officers of the industrial department, appreciating the urgency for getting this force off for the war zone, promptly took in hand every item of unfinished work that could be completed simultaneously with the work on the *Housatonic*.

On Wednesday afternoon the *Quinnebaug* stood in, and on Saturday, April 20, the *Canonicus*, both reporting themselves ready, making the squadron for the time complete. Except the *Roanoke*, no ship had taken advantage of a full week for preliminary shakedown. The last two ships took only three and four days. All of them, however, experienced bad weather, which tested their seaworthiness rather severely for so early in their new career.

It had been planned to supplement the preliminary specialty training of these new ships by giving them the assistance of experienced petty officers and men from the *San Francisco* and *Baltimore* during the two weeks period before sailing for abroad.

An urgent request had come from the British Admiralty about March 1, however, for the services of one or two minelayers to help out in laying a field in the North Channel to the Irish Sea, using British mines. The *Baltimore* was sent in response to this, sailing March 7 via Halifax. Consequently a double burden fell upon *San Francisco* alone, of testing the completed mines and giving some assistance to new ships in their training. Beginning at Hampton Roads, two instruction parties, of experienced gunner's mates with an officer, were transferred temporarily to the new ships in turn, for practice instruction and supervision of all the operations of testing, assembling, and preparing a mine for planting. This was supplemented on deck by sending to some of the new ships one or more experienced signalmen from *San Francisco*, in temporary exchange for equal numbers.

A change in plan came about at this time in compliance with the wishes of the Commander, Mine Force, for one or more planters to be sent in advance of the others to assist the *Baltimore*, so that they might together complete the mine field, on which *Baltimore* alone was engaged, in time to join the squadron for the northern barrage operations. For such an early departure, the *Roanoke* was the only one that could be considered; Capt. Stearns declared his ship would be ready to proceed as soon as some practice had been given in actual minelaying. Inspection of the crew and ship by the Squadron Commander confirmed this. Held only 16 days after leaving the shipyard, the inspection showed that the time had been utilized to the best advantage, the crew and the ship throughout being in a state most creditable to Capt. Stearns, and his officers and crew.

The following Monday the *Roanoke* held some minelaying exercises off Cherrystone, Va. Returning that night, she transferred to other

ships all but 160 mines, retaining these for drill, and at noon on Wednesday she sailed, the first of the new minelayers to proceed on active service. At Newport, R. I., she received a draft of 250 men for the mine bases in Scotland, proceeding thence via New York for the Clyde. As it turned out, all this was fruitless except for getting the men to the bases. The *Roanoke* was detained a few days in New York, waiting to join a convoy, and after arrival in the Clyde took no part in the *Baltimore's* mining operation, although prepared to do so. She arrived at Base 17, Invergordon, Scotland, a week before the rest of the squadron.

By Friday, April 26, as promised, *Housatonic's* repairs were completed and she went alongside the *Lake Superior* at the explosives anchorage to obtain her loaded mine cases. Next day at noon the *Canandaigua* did likewise, and by *Housatonic's* working all Saturday night the squadron was at last ready for the first cruise in formation at sea.

The four seagoing tugs, *Sonoma*, *Ontario*, *Patapsco*, and *Patuxent*, which had for some years past been performing the duties of fleet tenders, and for some months after the outbreak of war been engaged with the mine force in submarine net planting and in mining experiments, were fitted out to accompany the mine force abroad. The *Patuxent*, Lieut. J. B. Hupp, commanding, and the *Patapsco*, Lieut. W. E. Benson, were temporarily detached to escort a convoy of submarine chasers abroad via Bermuda and the Azores to Brest, but finally arrived at United States Naval Base 18, Inverness, Scotland, June 24, 1918, where they were subsequently employed for inspection and observation of mine fields and for communications between the mine bases. The *Sonoma* and *Ontario* remained with the minelayers until their departure for Europe. The *Sonoma*, Lieut. J. S. Trayer, accompanied the mine squadron on its trip across. The *Ontario*, Lieut. Edmund Delavy, accompanied a group of submarine chasers abroad and was then diverted to Queenstown for submarine patrol duty. Although it was originally intended to have 16 tugs, including the four above mentioned, attached to the mine squadron as minesweepers, it developed that their services in this capacity were not needed. Two tugs were able to handle the miscellaneous work at the bases; and, in view of the valuable wrecking equipment on the *Sonoma*, she was released on July 11, 1918, and ordered to Queenstown where she could be more profitably employed.

Sunday morning, April 28, Mine Squadron 1, consisting of *San Francisco*, *Quinnebaug*, *Housatonic*, *Canonicus*, and *Canandaigua*, got underway for Provincetown, Mass., where standardization trials and mine tests were carried out. On Monday, May 6, the squadron proceeded to Boston, where Mark IV drill mines were landed and the quota of Mark VI mines intended for the *Shawmut*,

Aroostook, and *Housatonic* were disembarked. That same night the squadron got under way for Newport, R. I., the point of final departure, conducting subcaliber practice and tactical exercises en route. The remainder of the week was spent in fueling and provisioning the ships and making final preparations for departure. A draft of 500 men destined for the mine bases in Scotland was distributed among the four large minelayers. The fuel ship *Jason* loaded with aviation stores destined for Killingholme, England, was ordered to cross in company with the mine squadron.

At midnight, May 11 and 12, the squadron, consisting of the *San Francisco*, flagship, *Housatonic*, *Canonicus*, *Canandaigua*, *Quinnebaug*, and *Sonoma*, got under way for Bases 17 and 18. During the forenoon of May 12, the *Jason* joined the squadron. On the first two days out heavy fog was encountered. The succeeding days were used for gunnery exercises, training and tactical exercises. Wednesday morning, May 15, the *Quinnebaug* showed the breakdown flag. She was taken in tow by the *Sonoma*, the squadron slowing to 7 knots. At the end of 24 hours repairs were completed and the *Quinnebaug* stood on under her own power. May 16, gunnery practice was held on a target towed by the *San Francisco*, in which all of the new ships were enabled to exercise their guns. On Friday the wind and sea increased until by 4 o'clock the *Jason* was unable to keep in formation, having to head off the course in long zigzags. Fortunately she had sufficient reserve speed to overtake the squadron when the weather moderated, regaining her position at about 7 p. m. the following day. She was again lost sight of on May 22 during another spell of bad weather. The steering gear of the *Housatonic* broke down on May 21, disabling her approximately for one hour, and again the following day, necessitating reducing the speed of the squadron while repairs were being made. In the meantime the *Sonoma* was sent on independently. By the original plans she should not have been in company with the squadron but should have turned off several days before to the Azores; but on reaching the separating point, she had proved so seaworthy and useful that it was decided to keep her with the squadron in case of further emergency. In making this decision, the chance had to be taken of bad weather separating her from the other ships on account of her not being able to make the necessary speed or hold the course. She was, therefore, sent on ahead while the rest of the squadron remained with the *Housatonic*. Up to this time the services of the *Sonoma* had been most useful. In addition to towing the *Quinnebaug* while she was broken down, she was of great use in carrying guard mail between the ships while they were en route and in assisting in the gunnery exercises. On Thursday morning, May 23, the *Sonoma* was overtaken and again joined the squadron. On this day the weather was the worst of any

experienced. The wind and sea on the quarter caused such heavy rolling that the *San Francisco* found it expedient to strike mines from the main to the second deck and fill her boiler and engine room double bottoms with salt water to improve her stability. There were no accidents, however, all ships standing the test very well. During the night and early morning the weather moderated, but fog had set in which continued until noon May 24. At daylight Saturday morning, the *Jason*, missing for four days, was sighted coming up astern. Fifteen minutes before the squadron was due at the rendezvous she took her position in the formation, thus making the unit again complete. At 4.52 a. m. four British destroyers appeared out of the haze ahead, then two to the southward and a little later three more to the northward, nine in all, with H. M. S. *Anzac*, half leader of the fourteenth flotilla, the flagship. This flotilla escorted the squadron past Cape Wrath, through Pentland Firth, and down Moray Firth to Cromarty, where the squadron arrived at 12.40 a. m., Sunday, May 25. Pilots, charts, and mine force instructions were placed aboard the ships at the whistle buoy. The *San Francisco*, *Canandaigua*, *Canonicus*, and *Sonoma* then proceeded to Inverness Firth and anchored off United States Naval Base 18. The *Housatonic*, *Quinnebaug*, and *Jason* proceeded into Cromarty Firth, Base 17, where the *Roanoke* was already lying. That forenoon, in reporting to Commander Mine Force, the squadron commander reported that all ships were ready for their intended duty.

The remainder of the squadron, consisting of the *Saranac*, *Shawmut*, and *Aroostook*, cleared the yards where they had been converted on May 23 and June 10, respectively. They were not delayed by uncompleted work, as the others had been; but the standardizing runs over the Provincetown course proved that the *Shawmut's* and the *Aroostook's* fuel consumption was much larger than had been reckoned, making their fuel capacity insufficient for the passage across. This threatened an indefinite delay, but the difficulty was solved by Capt. Cluverius and Commander Bulmer securing enough oil hose for the *Black Hawk* to fuel the ships at sea. By expeditious management the three mine planters, together with *Black Hawk*, were able to sail in company on June 16. The only oil hose obtainable quickly was of 4-inch diameter, nearly twice as heavy as that ordinarily used for fueling at sea. The first fueling was done in a gale of wind, and it was a novel undertaking for all concerned. Yet it was successfully accomplished. The second time fueling was done it was easier; and without further noteworthy incident the detachment arrived at Bases 17 and 18 in the evening of June 29. The *Baltimore*, having finished her minelaying off the north of Ireland under the direction of the British Admiralty, joined the others at Base 18 on June 2, thus making the squadron of Minelayers complete.

Chapter XIV.

COMMANDER MINE FORCE—APPOINTMENT, ARRIVAL IN EUROPE—PREPARATIONS FOR COMMENCEMENT OF MINELAYING.

As preparations progressed it became apparent that our mining operations were developing into one of the major war activities of the United States Navy, and it was desirable that it should be commanded by an officer of appropriate flag rank. Accordingly, Rear Admiral Joseph Strauss was appointed Commander Mine Force, United States Atlantic Fleet, relieving Capt. R. R. Belknap the middle of February, 1918.

This appointment was particularly suited to the capabilities of Rear Admiral Strauss, who had spent a large part of his service in the development and design of ordnance, and had preceded Rear Admiral Ralph Earle as the chief of that bureau. The minelaying program now in hand called for a vast expenditure of money for the production of mines which, as a type, were unknown and untested. Minor tests had, of course, been made of the constituent parts and were individually gratifying, but in any complex mechanism such as a mine, a torpedo, or a gun mount, an actual test of the completed unit under service conditions is the only true proof of its efficiency. At the outset it would seem that a mine should be extremely simple to design and construct. Such is far from the case. Prior to the development of this mine the United States Navy had never produced a really satisfactory mine. The demand for immediate antisubmarine measures was so urgent in order to prevent the loss of merchant ships from reducing the available tonnage below that required to successfully prosecute the war, that, tried or untried, it was necessary to begin at once, on a large scale, the manufacture of this new American mine.

After receiving his appointment as Commander Mine Force, Rear Admiral Strauss spent several weeks in Washington on temporary duty in the Office of Naval Operations, familiarizing himself with all information bearing on the operation and with the preparations then in hand, also reviewing the status of the work being done by the Bureau of Ordnance in connection with the production of the mines. Several days were spent in inspecting the new minelayers being fitted out at New York and Boston; then arrangements were made to pro-

ceed to Great Britain to complete the preparations necessary to enable minelaying to begin immediately upon the arrival of the squadron.

After reviewing the correspondence in Washington relative to the nature of the proposed mine barrage as then agreed upon, which, in addition to leaving Pentland Firth open, left a clear passage nearly 10 miles wide between the Orkney Islands and the western end of the barrage, besides some 110 miles which were deep mines only, Admiral Strauss wrote to the Chief of Naval Operations on March 7:

In considering the scheme to which the mine force's efforts are to be devoted, I desire to invite attention to the following necessary conditions to insure success:

First, every outlet to the broad sea must be closed by mine barriers. This includes the outlets to the Atlantic provided for in the proximate plans, as well as those to the Mediterranean through the Dardanelles and the Adriatic. There must be no leaks anywhere. While it would afford a serious check to submarine attack were our enemies' submarine bases confined to the Mediterranean, nevertheless an enemy so enterprising must not be given even so restricted an opportunity.

As to the means for accomplishing the end sought (the Mark VI mine), I think it too soon to predict success for this factor of the problem. I believe that the Bureau of Ordnance has done its work carefully and with the greatest intelligence, and we can only hope for the best results. I am prevented from a feeling of assurance, however, by the fact that actual experience with the mine is very limited. Unfortunately faults develop in every new mechanism, no matter how much skill and precision has been employed to close every avenue of failure. It would be too much to hope for the complete success of the new mine, and we must be prepared to make alterations in the mines at the operating bases, where the first reports of extensive tests will be received. At this date, as nearly as I can learn, no complete mines have yet been delivered for shipment, but parts have been delivered, and complete mines are expected shortly.

On March 12, 1918, Rear Admiral Strauss, accompanied by Lieut. Noel Davis, United States Navy, who had reported the previous day for duty as aide, sailed from New York City on the S. S. *New York*. Arriving in Liverpool, England, March 23, he proceeded at once to London and reported that afternoon to Vice Admiral Wm. S. Sims, Commander United States Naval Forces, European Waters.

The following five days were spent at London headquarters going over the recent developments in the status of the barrage, and in calling on the various officials at the British Admiralty interested in the enterprise.

On March 28 Admiral Strauss with Lieut. Davis left London, arriving at Grangemouth, Scotland, the same day, to call on Rear Admiral Clinton-Baker, R. N., who commanded the British minelaying squadron, which had been allotted to co-öperate with us in the North Sea barrage. Grangemouth, which is situated on the Firth of Forth, about 18 miles west of Edinburgh, was the British mining depot from which their first minelaying squadron operated. The afternoon was spent discussing the plans for minelaying and in inspecting the assembly plant.

The following morning, March 29, 1918, Admiral Strauss arrived at Inverness, where he was met by Capt. O. G. Murfin, U. S. Navy, commanding officer of United States Naval Bases 17 and 18. The day was spent inspecting Base 18, and establishing the headquarters of Commander Mine Force in the office building at that base.

The following week was occupied by inspection of the various stations under the jurisdiction of Commander Mine Force—Base 17, Kyle of Lochalsh and Corpach. By this time the work of construction at the bases had progressed to such a point that it would have been possible to begin the assembly of mines had the necessary mines and minelayers been ready.

On April 10 Admiral Strauss visited the Grand Fleet at Scapa Flow and called upon Admiral Beatty, Commander-in-Chief, to discuss the contemplated mine barrier. It was apparent that the Commander-in-Chief was anything but enthusiastic about a mine barrier across the North Sea. British minelaying had begun in area B, and skimming sweeps had showed that some of the mines had not taken the designed depth, and would have been dangerous to surface vessels crossing the field. This undoubtedly alarmed the Commander-in-Chief, and considering the restrictions on the freedom of movement of the fleet imposed by such a barrage, it is only natural that he was not enthusiastic. The main result of the visit, however, was to make definite arrangements for the escort of our minelayers while out at sea. No American destroyers were obtainable, and the mine squadron was thus totally dependent on the Grand Fleet for escort and could not leave the bases until such escort was provided. The number and type of escorting vessels was to depend upon the disposition of the German Fleet at the time of the mining operations. If the enemy fleet was at sea, it would necessitate sending out a portion or possibly all of the Grand Fleet. The commander in chief requested Admiral Strauss to telegraph him 48 hours before the squadron was ready to go out and escort would be arranged.

Capt. H. E. Mulleneux, R. N., was ordered to Inverness as liaison officer between the two services and as the representative of Rear Admiral Clinton-Baker at Grangemouth. Capt. R. E. Chilcott, R. N., was ordered to Invergordon in a similar capacity. While the bases were under construction (which was largely controlled by Admiral Clinton-Baker), these officers were of much assistance. However, as the construction drew to an end and the work of organization and administration became the predominant factors, the usefulness of liaison officers was very much lessened. One of the fundamental stipulations in the agreements for the execution of the barrage was that we should have entire freedom as to the manner in which our mines were to be laid. In our operations we were associated principally with the following British officials: Commander-in-Chief, Grand

Fleet; Rear Admiral, Invergordon, and the Senior Naval Officer, Inverness. As we were supplied with all the various British secret and confidential publications, the question of communications, etc., became in a few weeks equally as simple as our own, and to transmit all requests, communications, etc., via the liaison officer simply complicated matters and added an additional link to the chain. The result was, obviously, that there gradually became so little for them to do that they were finally ordered to more important duty. Just prior to the arrival of the minelayers the Admiralty, at the suggestion of the Commander-in-Chief, Grand Fleet, kindly offered to send one or two experienced officers to be attached to the staff of Admiral Strauss to assist with the administrative and communication work. Up to this time no difficulties of any kind had been encountered and their services were accordingly declined.

Much concern was caused when the U. S. S. *Lake Moor*, the fifth mine carrier dispatched to the bases, was torpedoed and sunk in the North Channel to the Irish Sea on April 11, 1918. The vessel was attacked about 11 p. m. and sank very shortly after being struck. The night was dark and rescue work was difficult. Fifteen survivors were picked up. The cause of alarm, however, was from a totally unexpected source. When the torpedo exploded it opened up the hold in which the firing devices for the mines had been stowed. The success of the North Sea barrage depended in a large measure in maintaining the secrecy of this device, and the most stringent measures had been followed from the place of their manufacture until the mines had actually been planted.

Each device was packed in a separate wooden box near the top of which handholes had been provided to facilitate handling. The top end of the firing device was heavier than the bottom, and as soon as it fell into the water it toppled over with the heavy end down, and the air trapped in the bottom of the case kept it afloat.

Four of these cases were picked up by a patrol vessel. As soon as this information was received arrangements were made to have the coasts in the vicinity searched and all cases found shipped to Base 18. Besides the possibility of an enemy submarine picking up some of these floating boxes, the accident occurred close to the Irish coast and just at a time when the Irish situation was most critical. Fortunately, however, it appears that none of these devices fell into improper hands. The Germans, at any rate, did not learn the secret of the American mines until possibly months later, when it might have been obtained from mines washed ashore in Norway.

In response to a cabled request, Lieut. W. K. Harrill, United States Navy, reported at Inverness on May 8 for duty on the staff of Admiral Strauss as force radio officer. During the war the Grand Fleet had greatly developed radio telegraphy and established special rules for

transmitting messages so as to prevent enemy stations from ascertaining by radio compasses the whereabouts of allied men-of-war. Lieut. Harrill was immediately sent to the Grand Fleet to familiarize himself with the current practice and the equipment which would be required for our vessels in order that they might be brought up to the necessary standards as soon as possible after their arrival. As soon as possible after the ships arrived each radio force, including the communication officer, was given one to two days thorough instruction by the force radio officer assisted by Lieut. Grant, United States Navy, radio officer from the U. S. S. *Delaware*, with special attention to the numerous confidential publications and also the salient points in British radio procedure. This was supplemented by a school established at Base 18 for ships in the harbor. When the squadron sailed on its first excursion June 7, all ships were equipped with the special apparatus, and on the next excursion the mine force conducted all radio communication in accordance with British procedure.

The work of establishing a suitable organization to co-ördinate the bases with the vessels, and the preparation of instructions for the force was the most important task of Commander Mine Force during the months of April and May. Mine parts were beginning to arrive and it then appeared that sufficient would be on hand by the time the squadron arrived to enable an excursion to go out immediately. It was mandatory therefore that no administrative oversight, such as insufficiency of provisions, supplies, current recognition apparatus, etc., should cause a delay in the operations.

The mine force instructions were drawn up to include not only the necessary instructions with regard to liberty, leave, patrols, repairs, routine reports, etc., which commonly comprise such a publication, but also specific instructions for passing the harbor defenses at Invernéss and Invergordon, obtaining water, coal and provisions, the proper means of obtaining miscellaneous supplies from Admiralty stores; special instructions for handling the various classes of mails; censorship regulations; train schedules; arrangements for handling liberty parties by British drifters allotted for this purpose; the various recreation facilities on shore for officers and men—in fact, effort was made to include in the one set of instructions all possible information. These instructions were prepared in loose leaf form, so that when it became necessary to make changes or additions it might readily be accomplished to maintain in one volume practically everything necessary for the operations of the force, and to eliminate the necessity of hundreds of miscellaneous letters on equally as many subjects which are always most confusing because they are so difficult to keep in touch with.

Special contracts were arranged by the force supply officer with local dealers for the supply of meats, vegetables, and other fresh provisions at fixed prices. A channel was dredged in Inverness Firth to permit minelayers to go further up the Firth to Beauly Basin, which is adjacent to Base 18. The Firth, which is shallow, was resurveyed and a new chart published. Moorings were laid to accommodate the minelayers in the more restricted anchorages.

Taut wire measuring gear was obtained for each vessel and held in readiness for installation on their arrival. This gear proved most valuable for navigational purposes. It consists essentially of a drum carrying 140 miles of fine piano wire. A suitable weight is secured to the end of the wire and dropped overboard. The wire as it is paid out is measured by a recorder which shows with remarkable accuracy the actual distance traveled over the ground.

Arrangements were made for Commander Mine force to act as the distributing authority for all United States and Allied secret and confidential publications. British chart portfolios were obtained for each ship. Special apparatus required for making recognition signals were also procured and held ready for the ships.

By the time that the squadron was due to arrive all preliminary work had been completed. The mine force instructions and necessary harbor charts were taken on board by the pilots sent out to meet the ships and bring them into Invergordon and Inverness upon their arrival.

Chapter XV

CHANGES IN THE BARRAGE PLAN.

In view of the formal approval by the Navy Department and the British Admiralty of the northern barrage plan as it existed on November 1, 1917, the Department, and more particularly the mine section of the Bureau of Ordnance, naturally assumed that such changes as might become necessary during the operation would be only of a minor character and that the major features, notably the location of the barrage on the Aberdeen-Ekersund line could be regarded as definitely fixed, and on this assumption the manufacture of the immense quantity of material required was taken in hand and pushed to the utmost. This assumption soon proved, however, to be incorrect, and from December until the cessation of hostilities there were so many changes in plan and so much resultant confusion in the manufacturing and shipping projects that the whole operation was seriously delayed, its success gravely hazarded, and its effect undoubtedly much reduced below what was to have been expected from the execution of the original proposition.

A communication of December 6 from the Admiralty to Admiral Sims, written after the subject of the laying and patrol of the barrage had been discussed in consultation with the Commander-in-Chief, Grand Fleet, stated that:

> It has become clear that there will be considerable difficulty in patrolling the eastern portion of the barrage as at present proposed, and in affording support by light cruisers, etc., if no Norwegian port is available as a base * * *. An alternative position for the barrage has accordingly been worked out on the line Orkney-Bergen in place of Aberdeen-Ekersund.

The various advantages and disadvantages of this change were outlined and the suggested change submitted to the United States for approval. The question was referred by Admiral Sims to the Navy Department for decision as soon as the proposal of change was received (December 7) which replied that:

> Unless reasons for change are fundamental, advantage of new location would not offset loss and delay by derangement of plan for mine material.

In this connection the British "History of Northern Barrage" states that the Admiralty in its communications to the commander in chief, Grand Fleet and to Admiral Sims, made the following points among others relative to the proposed change:

> The mine barrage is of no value unless the deep portions are patrolled, and the patrols must be adequately supported to be effective * * *.

The provision of the 42 destroyers for the patrol of the eastern area would also prove extremely difficult without assistance from the Grand Fleet.

The material will be equally suitable for the new line.

The proposed alteration should not delay completion.

The last two points quoted were entirely in error so far as American mine material was concerned, since the proposed new location of the barrage in deeper water would necessitate increased lengths of mooring ropes and, as the manufacture of material was well along, delay was inevitable.

The proposed change was based on broad strategical and tactical grounds and the Navy Department was forced by circumstances to agree to it, though most reluctantly.

In reply to the Admiralty communication of December 6, a memorandum was prepared by the planning section of Admiral Sims's staff and issued January 1, 1918, which reviewed the entire situation and set forth the views of the United States in part as follows:

The second position considered in this memorandum is the one now proposed by the British Admiralty and accepted in principle by the Navy Department. There are many factors pro and con that entered into a choice as between the two positions, but of these a single factor controlled, viz: That the new position is deemed best by the Grand Fleet, upon which will rest the responsibility for the support and patrol of the barrage. The new position gives greater freedom of movement and greater ease of support to surface vessels, while it imposes corresponding difficulties upon the operations of enemy surprise vessels. The change in position accepts the handicap of an average increase in depth of water of about 15 fathoms. This handicap might be considered serious were it not for the fact that the whole barrage is based on the assumption that an effective mine field can be laid in 1,000 feet of water.* If this assumption be true, then whether a portion of the mine field be laid in 40 or in 60 fathoms of water is not material, except as the changes in plan introduces delay.

It will be noted that the original line extended from mainland to mainland, while the new line extends from island to island and has in it passages completely navigable to submarines. This condition is, in our opinion, undesirable.

The proposed character of the barrage does not provide for the full accomplishment of the mission. The proposed barrage will not close the northern exit from the North Sea because—

(*a*) The barrage is not complete in a vertical plane in areas B and C.

(*b*) The barrage is not deep enough.

(*c*) The Pentland Firth is open.

(*d*) The waters east of the Orkney Islands, for a distance of ten miles, are open.

(e) Patrol vessels on the surface are not sufficiently effective in barring passages to submarines, as witness the Straits of Dover.

The barrage is to be a great effort. It is our opinion that nothing short of a sound design will justify the effort.

The requirements of a sound design are, the extension of the barrage complete in the vertical plane from coast to coast.

The necessity for an opening in the surface barrage is recognized, but it is held that this opening should be in the surface barrage only, and that the deep barrage should be widened so that the difficulties of navigating the opening submerged may be practically prohibitive.

In conclusion it was tentatively decided (by U. S. planning section):

1. To accept the new position of the barrage as outlined by the British Admiralty.
2. To urge that the barrage be completed in the vertical plane from coast to coast, except an opening in the surface barrage at the western end and in Norwegian territorial waters.
3. To carry the barrage to 295 feet (British plans 200 feet).
4. To have surface mines fitted with 70 foot and other mines with 100 foot antennae.

As then proposed, the barrage was divided into three areas designated and located as follows:

Area B. A 20 mile wide section extending 50 miles to the eastward of the Orkney Islands.

Area A. A section 50 miles wide extending 134 miles to the E. N. E. from the eastern end of the area "B".

Area C. A 50 mile wide section extending from the east end of area "A" 60 miles E. S. E. to Norwegian territorial waters.

The United States was to furnish the mines and material for and lay both deep and surace fields in Area "A." Great Britain was to provide and lay deep mine fields in Areas "B" and "C", and furnish trawlers and fast vessels to patrol these two areas.

The British Admiralty plans division answered the above memorandum with the opinion that—

The stopping power of the mine barrage should not be overrated. It is the patrol craft armed with various antisubmarine devices on which we must rely to kill the submarines. It is on the mine fields that we rely to give us intensity of patrol. Until we have proved the efficiency of the American mine field, we must look on it as a bluff. We must not attempt to put the bluff too high by notifying an area up to the 3-mile limit of Norway. The navigation of Pentland Firth by submerged submarines is considered impracticable. As it is the patrol craft we rely on to destroy the submarine, it is not considered that leaving the approach to Pentland Firth uncovered is of vital importance.

It was further stated that it was not considered necessary to carry the barrage to a vertical depth of 300 feet, that there was no reason why the American portion should not be laid in accordance with the United States views, but that the Admiralty would be prepared to extend their barrage to a greater depth, if found necessary, and to mine the surface if that should become desirable.

In view of these differences of opinion the U. S. planning section prepared a memorandum of January 12, containing its understanding of the status of the mine barrage and submitted it to the British planning section for confirmation in order to reconcile the various points and further unify the effort, by reducing to writing a concrete plan which would be acceptable to both navies. Further than the agreements regarding the supply of all minelaying operations and the assignments of provision and laying of mines in the areas as previously noted, these efforts met with failure in so far as formal

agreement on a written plan was concerned, the British apparently desiring to reserve the privilege of altering the plans when expediency so dictated while considerable scepticism existed as to the ability of the Americans to execute satisfactorily their part of the project. The above mentioned characterization of the American mine field as a mere "bluff" was more or less indicative of the British attitude.

The Admiralty did, however, accept the principle of surface mining in Areas "B" and "C" should experience indicate that the surface barrage be more effective in preventing the passage of submarine than the surface patrol.

After this discussion the planning section of the Admiralty not being in a position to enter into any definite signed agreement, nor to definitely recommend it to the Admiralty, Admiral Sims requested the status of the plans in so far as the Admiralty's agreement with them was concerned. This resulted in a statement of January 18 which included:

United States to be responsible for provision of mines and minelayers for area A. Great Britain for areas B and C. Area A to be mined from 10 feet below surface to as near 300 feet as the American mines will permit.

Areas B and C to be mined from 65 feet below the surface to 200 feet.

When this belt is effectively mined, the question of extending the mine fields to a greater depth will be considered.

The desirability of extending the deep mine fields to the surface of areas B and C will be considered when the situation has developed further * * *.

Thus early in January the character of the proposed barrage became so modified as to bear little resemblance to the original plan and the original faith of its proponents in its effectiveness was no longer felt to be justified. It was felt in America, in view of the attitude of the Admiralty and the Commander in Chief of the Grand Fleet, that the British had no real faith in the American mine and were not whole-heartedly supporting the project. In particular, the allocation of both ends of the barrage to the British to be mined with an inferior mine in an incomplete manner, and the further decision that the American part of the barrage was not to be patrolled were most discouraging.

Not the least discouraging feature of the situation to the Bureau of Ordnance was the state of flux of the barrage plan and the obvious reluctance of the Admiralty to commit itself to definite plans. The British authorities had the appearance of not daring to give up the whole operation for fear of possible later criticism and at the same time of not being willing to cooperate to make it successful.

In Admiral Sims's review of the activities of his command it is stated, in effect, that throughout the discussion of the barrage project it became apparent that the Admiralty was influenced by two considerations which may not clearly appear in the correspondence and

records, but which should not be underestimated in considering the mine field historically:

First, the proposed effort on the part of the United States Navy Department was such a handsome offer from an ally that, even if there were doubts of its success, it would be poor policy to put only discouragement in the way of those who were willing and anxious to go ahead with the project. The Admiralty naturally wanted to avoid any possibility of not having tried the mine barrage, and subjecting themselves to possible later criticism on the score that it was necessary and would have worked had it been tried. In other words, the Admiralty at first was very dubious of the success of the field, but considered the proposals for the above reasons more seriously than they otherwise would have. As the details of the plans developed and the reports of Mark VI mines were received, there was a very notable increase in the enthusiasm for the project. At the start there was no enthusiasm at all. Later there grew to be considerable.

The second consideration which should be mentioned in explaining the Admiralty's policy toward the project was its effect on possible fleet actions. The Navy Department considered it almost entirely in the light of an anti-submarine measure. It was apparent that although nominally under the Admiralty in London the planning for the Admiralty in such matters as would in our organization be dealt with by the Office of Naval Operations, rested almost exclusively with the officers of the Grand Fleet in spite of the existence of a Plans Division in the Admiralty. Naturally they considered it largely from their own viewpoint, and in studying possibilities of the barrage they were influenced by the fact that even if it did not work it might be something which would force a general fleet action. If there were a serious attempt made by the Germans on the mine barrage itself, or raids on the vessels engaged in working on it, cruiser actions at least would be probable and with the arrival of supporting units it was quite possible that the two fleets might meet. They thought that even if it did not work as a mine barrage it might be a bait for a fleet action. It would make it harder for raiders to get out. So long as the Grand Fleet did not have its freedom of movement restricted (and the fleet was by no means so thoroughly convinced of the safety of the British mines in the deep mine fields as the Admiralty was) they had no objection to it and were rather inclined to favor it for the reason that it might help them meet the German High Seas Fleet. These reasons were at times mentioned and were very apparent in discussions, but are hardly evident in the records and were certainly not emphasized by the Admiralty in the correspondence. It appears very essential, however, to a good historical understanding of the northern barrage that they should not be overlooked, but should be most particularly mentioned.

Another thing which might be mentioned in this connection is that later in the discussion when the policy of the extension of surface mines into the end areas was considered, this project was proposed and pushed by the United States planning section and was always fairly well considered by the planning section in the Admiralty, but an extremely large percentage of what opposition there was to it came from the Grand Fleet, and it was only very grudgingly that the Admiralty, considering the views not only of its own planning section, but also the recommendations from the fleet, consented to the modification of the mine barrage, which later resulted in putting surface mines in areas which were at first intended to have deep mines only, although the United States had argued for surface mines in these areas as well.

The fundamental idea on which the mine section of the Bureau of Ordnance designed the new mine and proposed the northern barrage was that the barrage would be complete from coast to coast and that it would be patrolled so that enemy submarines would be

UNITED STATES SQUADRON IN PLANTING FORMATION IN THE NORTH SEA.

(Page 109.)

(Page 111.) MINELAYING FLEET PROCEEDING TO SEA ON A MINELAYING EXPEDITION.

MINELAYING FLEET, NORTH SEA, PROCEEDING TO SEA.

(Page 113.)

96-4

SQUADRON 1 STARTING ON A MINE LAYING "EXCURSION."

(Page 114.)

forced by the presence of patrols either to turn back or to risk almost certain destruction by trying to pass the barrage submerged. Any departure from this principle meant ineffectiveness.

The following remarks quoted from a memorandum prepared by an officer of Admiral Sims' staff, at the time the change in plan was under discussion, are interesting:

Position.—The more northern position accepts disadvantages as regards depth of water in order to obtain certain strategical advantages. This statement, however, is no more true now than it was when the southern line was previously decided upon by all concerned. If we are disinclined to admit that a mistake was made in the original instance by choosing the southern line, we must now show that the reasons for the shift to the northern position are new reasons or things which did not hold true at the time of the other conference. The only new conditions mentioned are that whereas previously it had been hoped to obtain a Norwegian base one is now no longer considered possible. The other reason is the increased activity of enemy surface craft. Taking the first of these reasons, I am inclined to suspect that there is not much to it. I think that a Norwegian base now is just as easily possible as one previously was. I base this on a recent conversation with Col. Breckinridge who is naval attaché in the Scandinavian countries and who had just been in Norway. There is probably no useful point, however, to trying to get behind this reason if the Admiralty really sees fit to advance it. The second reason of the increased activity of enemy surface craft looks like an excellent one after the losses of the two Norwegian convoys recently. Steps have been taken to improve the Norwegian intelligence service as to information about the enemy craft coming out of Skagerrak but this will probably be offset by the increased incentive for the Germans to send out raiders.

In looking over all the papers I can not help but believe that in the early conferences the fleet was not so very thoroughly represented, and there were people from the mining division who explained that sending the fleet over a deep British mine field was nothing to hesitate about. The fleet was in Rosyth, south of the proposed barrage, and was generally expected to stay there. Now with the fleet back in Scapa I believe that they are beginning to assert their views to a greater extent and that at least a large part of their insistence to move the southern end north to the Orkneys arises from their disinclination to navigate over British deep mine fields. This is not a reason which there is much point in emphasizing from the Admiralty's standpoint, so it was really not presented but the argument was made along other lines. Except as a matter of being perfectly frank with us I do not think that it matters so very much whether the real reasons for the change in the position of the barrage are those which they mention or others, equally good ones, which they hesitate to talk about. For my part, I believe that the fact that Admiral Beatty, who is going to support this mine field, says that it must go in the northern position finished the whole discussion and is something that we need not go behind.

Character of barrage.—I believe that the width of the "C" area along the Norwegian coast is much too great. Leaving it this wide seems to have been based upon the idea:

(*a*) It is not good policy to unnecessarily crowd the Norwegian coast with the notified area if it can be avoided.

(*b*) They have an idea of wanting to do the whole project on a 50–50 basis and the deep mine fields of this width are symmetrically arranged. This is no reason at all.

I can not help but doubt when I compare the width of this area with the Straits of Dover and consider all conditions existing in that locality, that the deep mine

field, particularly on the Norwegian coast, will not be efficient and it will have to be later modified by strengthening with surface mines. I have met officers in the Admiralty who privately expressed the same opinion and stated that in the end they would be proved correct by the addition of surface mines in Area "C."

Length of antenna.—Seventy feet for the top mines and 100 feet for the other rows. This is based on the hope that at greater depths 100 feet may be effective and that at any rate it will probably drive the boat to the surface, in which case the 70 foot antenna of the top row of mines, which should be nearest to the edges of the field, should get the boat and destroy it. Seventy feet all around would be better perhaps, but submarines can now go so deep that it becomes a necessity to try to stretch out the barrage vertically, even at the expense of some other small advantages.

Character of mine fields on the Norwegian coast.—The whole mine barrage scheme is more or less of a tentative nature, because it is so big an undertaking that it can not in all ways be perfectly designed to meet every conceivable counter measure. Also it would be uneconomical and inefficient to try to plan it with any such final ideas in mind. The final appearance of the barrage before the end of the war is something which one would have to be extremely rash to care to prophesy. There are a few things which our personal opinion leads us to believe will be the most urgent modifications and the ones which we will see first. In my case I look to see the Norwegian end of this field protected on the south by perhaps one system of antenna mines before any great time has elapsed and the notified area appropriately extended. This will relieve patrol craft in the "C" area of part of their difficulty.

The question of who takes the "C" area has not yet been decided. We have gone ahead and made mines with long lengths of specially small diameter mooring line which will do in this place. I foresee that we will eventually have to do something with mines of this nature, and think it would be a very good thing to make a careful analysis of conditions in Area "C," even although it is not our own area, with the idea of seeing whether later on we may be able to use these mines additionally. Mines intended for deep water like these can be laid in shallow water, but mines with short lengths of wire (and the diameter of the wire is different) can not be used in deep water. Can we not compromise in our present disagreement as to who takes the Norwegian area by finding both kinds of mines are needed and helping to do that too? In Area "B" the necessity is by no means so great. The Fleet does not want any surface mines to obstruct its passage, but after finding patrolling rather difficult it may look favorable upon a project of extending the surface mine area. The water is not deep in this place. We will need no surface mines here until after Area "C" is taken care of. It is not safe to look beyond that point * * *.

In order to focus attention upon the various points still unsettled there was then prepared by Admiral Sims a paper dated February 19, setting forth the different items in parallel columns and this was submitted to the Admiralty. This was answered on February 26, but as stated in a letter from Admiral Sims to the Office of Operations on March 2, "It appears that although a number of the points have been cleared up * * * there still remains a decided difference of opinion in regard to certain important points."

It is believed that the Admiralty's disinclination to extend the Mark VI mines to the end areas until their efficiency has been demonstrated in Area "A" is not based on sound reasoning, for with the efficiency of the mine Area "A" or in any other area the whole success of the barrage stands or falls * * *. If the more efficient mining of these end areas is delayed, until the inefficiency of patrols in these areas is demonstrated, it is believed that much valuable time will be lost in a case where time is a most vital element.

Anticipating the necessity for this end area surface mining Admiral Sims, on April 9, cabled to the Navy Department requesting preparation of mines for Area "C." Meanwhile deep mining had been commenced by the British in Area "B" but, owing to unexpected difficulties with the British mines themselves, the operations were suspended before one complete line had been run.

The Commander in Chief of the Grand Fleet was much disturbed by these unsatisfactory results and the Admiralty felt that they could not continue laying the barrage in Area "B" until the faults had been discovered and removed.

Shortly after this, in a letter of April 18, 1918, to the Officer of Operations, Admiral Sims stated:

> Owing to the apparent uncertainty in the Admiralty as to the further execution for the plans of the Northern Barrage, I caused the matter to be brought up at the staff meeting this morning at which I proposed the following: We lay two single lines of surface mines over the southern portion of Area "C." British to lay one "system" of deep mines over the northern portion of Area "C." Area "B" to be deep mined as already planned, except that the mines are to be carried close up to the coast (Islands) without leaving the 7 mile channel now shown on the chart.

The proposal in so far as it applied to Area "C" only was accepted by the Admiralty formally on April 20.

Thus it will be seen that the original contention of the United States authorities in regard to the need of a complete barrage, including surface mining in the end areas, was not allowed to rest upon the proof of ineffectiveness of surface patrols, for this particular barrage, but the inefficiency of such patrols, as amply demonstrated in previous mining efforts, was at last permitted by the Admiralty to outweigh their desire for wide passages for the Grand Fleet.

But this was still only a partial conversion to the idea, for Area "B" still remained in question. Here all mining was stopped. The failure of the British deep mines was responsible for this, and although the necessity was still acknowledged as noted in the Admiralty's letter of May 10 to Admiral Sims it was said:

> The deep minefield in area "B" can have no effect in restricting the areas through which the submarines can pass and should not therefore be considered an essential part of the scheme.

Although a verbal agreement was made that as soon as the defects of the deep mines could be remedied the laying of Area "B" would proceed, the safety of ships passing over the field could never be guaranteed and in the memorandum of the deputy chief of naval staff (Admiralty) received by Admiral Sims on July 25, the conclusions were that either Area "B" was to be swept and left clear or that it should be completed with deep and shallow mines. Also that if the latter were done the channel between the western extremity

of Area "B" and the coast line would be so narrow that it would not be available for general purposes.

The width of this channel, according to a report of the technical committee (Admiralty), "will be eventually decided with the Commander in Chief, Grand Fleet, but in view of experience at Dover and difficulty of anti-submarine patrolling without mines it should not be unduly wide."

To further the desire to actually complete the barrage the Bureau of Ordnance was asked on July 31 to prepare American mines for Area "B." Then as a result of a consultation between the Commander in Chief, Grand Fleet, and Admiral Freemantle about August 25 a note was addressed to Admiral Sims including items to the effect that:

> It will be seen that the Commander in Chief is very averse to proceeding at a quicker rate than step by step, and that he considers that the next step should be mining up to the 10-mile limit (10-mile channel east of Orkneys). There is a natural reluctance to close the North Sea unless it can be actually guaranteed tight.
>
> It is suggested therefore that we commence on the 2d of September to mine Area "B" up to the 10-miles without declaring the area, and that when we eventually do notify the area it shall include right up to the coast. Moreover, the fact that the northern patrol force has failed as a killing force has altered the situation.

On September 9 surface and deep mines were actually laid in Area "B" on a combined excursion of the British and American mine-laying squadrons.

With the gradual closing of all areas, enemy submarines commenced to use Norwegian territorial waters to make the passage. On discovery of this fact, the Norwegian Government, after much negotiation and delay, announced September 29, its decision to mine Norwegian territorial waters, which had the effect of closing this gap.

Many minor changes in plan and material occurred from time to time as will be noted in other chapters of this narrative, but the foregoing is sufficient to show the uncertainty and confusion prevailing throughout the operation.

Chapter XVI.

MINING OPERATIONS.

Early in March, 1918, the British were ready to begin minelaying in Area "B." Work started on March 2, and successive operations took place on the 11th, 19th, and 22d, laying a single row of mines in the southern part of the area at depths of 65, 95, and 125 feet.

On March 22 H. M. S. *Gailardia* was sunk in the vicinity of this field while engaged in the work of laying buoys to mark the North Sea barrage. Minelaying was stopped pending investigation. The loss of this vessel caused considerable alarm in the Grand Fleet, and on March 31 the Commander-in-Chief cabled to the Admiralty: "* * * the chief point to settle is, are these mines safe if within 45 feet of the surface? Unless this can be guaranteed the policy of laying mines in vicinity of principal fleet base is wrong."

As a result of this the Admiralty wrote the Commander-in-Chief on April 24, 1918, that "It is not at present proposed to lay any more mines in Area 'B.'"

From the United States point of view this was a most unsatisfactory development, for it was our firm conviction that to make the barrage a success it was absolutely necessary that the mines should extend completely across the North Sea and that surface mines should be laid in Areas "B" and "C" as well as in Area "A." After repeated representations a partial concession was reached on April 20, when it was agreed that we should lay two rows of surface mines in Area "C" to the southward of the contemplated lines of British deep mines. This eliminated the necessity of patrols in Area "C" for the purpose of forcing submarines down into the deep mines, although a smaller patrol was still desirable in order that submarines which were only partially disabled by mines might be destroyed before they could reach an enemy base. The announcement of the Admiralty that no more mines were to be laid in Area "B" was most serious. Admiral Strauss recommended that unless the British Government definitely agreed to carry out the plan of making the barrier at least as complete as had previously been agreed to, that the United States should withdraw from the operation entirely. Our views in regard to mining Area "B" were presented to the Admiralty whenever occasion permitted, with the result that a verbal agreement was at last reached that as soon as the defects of the mines could be remedied the mining of this area would be resumed.

On April 26 notification was issued in Notices to Mariners that all shipping was to avoid the area bounded as follows:

(1) Lat. 59° 12.5′ N., long. 4° 49′ E.
(2) Lat. 59° 29′ N., long. 3° 10′ E.
(3) Lat. 58° 25′ N., long. 0° 50′ W.
(4) Lat. 59° 20′ N., long. 0° 50′ W.
(5) Lat. 60° 21′ N., long. 3° 10′ E.
(6) Lat. 60° 00′ N., long. 4° 56′ E.

and thence along the western limits of Norwegian territorial waters to position (1). The area above outlined included Areas "A" and "C," but, as originally intended, Area "B" was not included.

Prior to the commencement of work on the North Sea barrage the British had been carrying out minor minelaying operations in various localities. In the early spring of 1918 the enemy's submarines were very active in the Irish Channel, and it was decided by the Admiralty to lay a deep mine field off the North Coast of Ireland in the North Channel.

As all British minelayers were constantly employed elsewhere, the Admiralty approached Vice Admiral Sims on the subject of lending a United States minelayer for this purpose. The U. S. S. *Baltimore*, Capt. A. W. Marshall, United States Navy, was promptly detailed and arrived at the Clyde on March 8, 1918, being the first American minelayer to arrive in British waters.

The *Baltimore* remained at the Clyde for about three weeks, during which time she was fitted out with paravanes and taut wire measuring gear, and opportunity was taken to send parties of officers and men to Grangemouth for instruction at the mining depot, and on board the British minelayer *Princess Margaret* in the British H–2 mine and Mark XII sinker.

During this period Capt. Marshall visited Grangemouth to discuss matters with Rear Admiral L. Clinton-Baker, C. B., R. N., who had been ordered by the British Admiralty to arrange all details in connection with laying the above-mentioned mine field.

Capt. Marshall, United States Navy, and Capt. Lockhart Leith, D. S. O., R. N., then visited Larne, Buncrana, Ardrossan, and Lamlash, and discussed the procedure for carrying out the mining operations with the senior naval officers at those ports.

Lamlash was selected as the base from which the *Baltimore* should operate. Mines were supplied by train from the mine depot at Immingham. These mines were the British H–2 star, with Mark XII sinkers (fixed moorings). They were fitted with deep switches and calibrated so as to be inoperative when planted nearer the surface than 50 feet. No sinking plugs were used.

The field was designed to consist of one line of mines at 65 feet where the water was less than 20 fathoms; one line at 65 feet and

one line at 95 feet in water between 20 and 30 fathoms; one line at 65 feet, one line at 95 feet, and one at 125 feet in water of 30 fathoms and above. The mines were to be laid in groups of four, spaced 100 feet between mines in each group, and groups to be 300 feet apart.

All operations were carried out at night, the *Baltimore* being screened by two destroyers. The operations consisted of the following:

13th–14th April, laid 179 mines 65 feet below L. W. O. S.
18th–19th April, laid 120 mines 95 feet below L. W. O. S; 60 mines 125 feet below L. W. O. S.
21st–22d April, laid 180 mines 65 feet below L. W. O. S.
27th–28th April, laid 180 mines 95 feet below L. W. O. S.
1st–2d May, laid 180 mines 125 feet below L. W. O. S.

The following extract from a report made by Rear Admiral Clinton-Baker, R. N., who was in general command of the *Baltimore's* operations, is quoted:

> It is considered that the *Baltimore* laid the lines of mines (as planned) with extreme accuracy; this reflects the greatest credit on Capt. Marshall and his navigating officer, having in view the strong cross tides (3 to 4 knots) that existed in that locality.

On the 6th May, minelaying operations were discontinued by orders from the Admiralty on account of a skimming sweep of the mine field having disclosed several shallow mines at the northern end of the field, due in all probability to the very uneven nature of the bottom. This skimming sweep was made at a depth of 30 feet, giving from 30 to 33 feet at the cutters. Actean sweeps were used. While the sweeping was in progress, one mine was swept up which had 60 fathoms of mooring cable attached. As all mines planted in this field were set for fixed moorings of approximately 45 fathoms, tests were immediately carried out at Grangemouth to ascertain the reliability of the locking device in the Mark XII sinkers. The results of this test showed the possibility of the locking nut stripping the threads and allowing the full length of the cable on the reel to run out. These sweeping operations began on May 1 and continued until May 5, when a mine was exploded by the sweep in position latitude 55° 33′ 15″ N., longitude 6° 42′ 45″ W. Extensive countermining immediately took place in lines A, B, and C, lasting for a period of between 15 and 30 seconds, and apparently detonating all mines in these three rows. As described by the officer in command of the sweepers:

> There was a continuous series of explosions as rapid as the fire of a Maxim gun, with occasional pauses, in which separate and distinct reports could be heard, followed by a period of intensified sounds, in which separate explosions were indistinguishable.

Sweeping operations were resumed in the North Channel on the 20th of May, when the southwestern portion of D line was skim

swept at a depth of 36 feet—nothing found. The following day sweeping continued, but again nothing was found. These sweeping operations continued until the 29th May, when the entire North Channel deep mine field had been swept at a depth of approximately 36 feet. A few shallow mines were found in lines D and E, but not nearly so many as were found in the other lines. Soundings obtained by the vessels engaged in making the skimming sweep showed considerable irregularity in the bottom and much variation from the survey soundings which were used for setting the fixed moorings. This was particularly true of the northeastern part of the field.

Prior to the discontinuation of the laying operations by the *Baltimore*, it appeared as though it would be impossible for her to complete this mine field in time to join the mine squadron for the first operation in the North Sea barrage. Accordingly, the Navy Department was requested to send either one or two of the new minelayers which were most nearly completed to assist her in order that all vessels might be available as soon as operations could begin in the North Sea.

In response to this request the *Roanoke* sailed from the United States on May 3. Before her arrival, however, the *Baltimore's* operations in the North Channel had been discontinued. The *Roanoke* remained several days at Lamlash, then sailed for Base 17, where she arrived a week ahead of the other minelayers.

The *Baltimore* remained on the west coast for several weeks in order to perform experiments for the British in connection with minelaying and minesweeping, then proceeded to Base 18, where she arrived on June 2, 1918.

In the meantime preparations for the commencement of mine laying had been completed. Early Sunday morning, May 26, 1918, the *San Francisco*, flagship of Mine Squadron One, accompanied by the *Canonicus*, *Canandaigua*, *Housatonic*, and *Quinnebaug*, arrived at Bases 17 and 18. The Squadron Commander reported that all vessels would be ready to commence minelaying as soon as as they had been watered and refueled. The delivery of mine parts, however, had not come up to expectations and prevented the beginning of operations at once. All of the necessary mine parts were on hand except the antenna floats for mines planted at the lower levels, and it was necessary to wait until a mine carrier had arrived before sufficient of these floats were on hand to enable the necessary numbers of mines to be assembled for the first excursion.

The first excursion was to be a joint operation between the British minelaying squadron, which had been designated by the Admiralty as the first mine laying squadron, and our vessels which they had named the second mine-laying squadron. We reported that our squadron would be ready to go out on June 6, but it was necessary

to wait one day while the British completed the assembly of their mines. The United States squadron left the bases, rendezvoused outside Cromarty Firth with the British destroyers sent to escort them, then proceed via the swept channels and across the North Sea until Udshire Light was sighted on the coast of Norway. This was used as the point of departure, being the nearest point of land to the position in which the mine laying was to commence.

No difficulties were encountered by any of the vessels with their mining installations or the lack of experience of their crews. The mines were laid with accuracy and precision and the ships, in spite of the various types which constituted the squadron, maneuvered well together.

When the mine field was first proposed it was intended to plant the mines at intervals of 150 feet, but tests conducted by the *San Francisco* while in the United States showed this distance to be impractical on account of the damage done to adjacent mines when one mine exploded. As a result of these experiments it was finally decided that 250 feet was the minimum distance at which mines could safely be planted, and this spacing was used on the first excursion.

Shortly after minelaying had commenced mines began to explode prematurely. This continued as long as the squadron was in touch with the mine field, but the frequency of the explosions decreased rapidly after the laying was completed. By counting the explosions it was estimated that between 3 and 4 per cent of the 3,385 mines laid had blown up. Some of these explosions took place almost immediately after the mines went overboard, severely shaking the vessels from which they were laid. Others did not explode until days after they had been in the water. These explosions, which occurred after each excursion, presented the most baffling problem which the mine force was called upon to solve. Although a loss of 4 per cent of the mines did not seriously reduce the efficiency of the barrage as a whole, such a condition was, nevertheless, undesirable and every effort was immediately applied to ascertain the cause.

There appeared to be some doubt as to whether the spherical-cylindrical buoys, which were dropped upon completion of mine laying to mark the end of the field so that the next excursion could commence as close as possible without danger, would survive the weather until the ships again went out. The Commander-in-Chief, Grand Fleet, was therefore asked to send two sloops or trawlers to stand by these buoys and assist the squadron in finding them when taking their departure on the following operation. These vessels while performing this duty were able to supply much valuable information to the Commander Mine Force, as most of them were fitted with listening devices which enabled them to hear and record the

explosions occurring between successive operations. From 1 to 11 explosions were noted daily for seven days. By that time practically all explosions had ceased. This seemed to indicate that slow leakage was probably causing these later mines to fire.

Of the 12 marker buoys which were dropped at the end of the field only three broke adrift during the following three weeks. Their endurance was sufficient for the purpose intended and the Commander-in-Chief was informed on July 27th that vessels would no longer be required to keep watch on the buoys.

The British minelaying squadron proceeded separately to Area C where their mines were laid on the same date that ours were put down.

As a result of the joint studies of the American and British planning sections, a somewhat radical but beneficial change in the nature of the field in Area "A" was adopted shortly after the commencement of active mine laying. As originally agreed upon the American mine field in this area was to consist of three systems, each system comprising one line of mines at 80 feet, one at 160 feet, and one at 240 feet. This arrangement gave an equal density of mines from the surface to the bottom of the barrage. Since, however, there was to be no patrol in Area "A," submarines attempting to cross the field would undoubtedly do so on the surface where the damage in case of striking a mine would be the least. Also, submarines being pursued by slow vessels would prefer to proceed on the surface where their chances of escape were best.

Accordingly it was decided that the third system instead of consisting of one row of mines at each of the three depths, should consist of three rows of surface mines, i. e., 80 feet submergence.

Immediately following this alteration it was decided to double the number of rows of mines in Area "A." The original plan had called for mines to be laid 150 feet apart, but due to the damage caused by the explosions of neighboring mines and the possibility of countermining, this distance had been gradually increased until it had become 300 feet—just twice the original figure. It was therefore necessary to double the number of systems to give the field the same approximate effectiveness as originally planned.

After the above two changes the barrage in Area "A" was to consist of:

10 rows of mines at 80 feet submergence.
4 rows of mines at 160 feet submergence.
4 rows of mines at 240 feet submergence.

As the mooring ropes for the mine anchors were cut in different lengths to correspond with the three depths at which mines were laid, the above change necessitated supplying a great many more anchors for 80-foot mines and fewer for the deeper levels. Fortunately the

Bureau of Ordnance was able to meet the new demands without causing delay in the operations.

Shortly after minelaying had begun in Area "C" the Norwegian Government issued a decree to the effect that belligerent submarines equipped for use in warfare must not traverse or stay in Norwegian territorial waters except by reason of stress of weather or to save life. Breach of this prohibition would expose them to armed attack without warning. Norway also reduced the limits of her territorial waters from four to three miles, since the former figure was not recognized by the principal belligerent nations. This decree, rigidly enforced, would have had the same result as if British and American mines had been laid right up to the Norwegian coast instead of stopping at their territorial waters, but there was good reason to believe that the decree was not enforced against German submarines.

After the completion of the first excursion further minelaying by the United States mine force was temporarily prevented by the non-receipt of mining material. The first excursion had used up all but three of the antennae floats for the lower level mines. Tests were conducted in Loch Ness to ascertain whether the antennae floats designed for the upper level mines would withstand the deeper immersion.

There were plenty of these floats on hand and they could have been used had they been suitable. They would not, however, hold up when submerged to the necessary depth. The only other possible alternative for continuing mine laying was to lay the two lines of surface mines in Area "C," which we had recently agreed to do, but here again we were delayed. Although it was expected that the British would agree to our laying surface mines in this area and the mines had actually been ordered several weeks before the concession had been obtained, there had not been sufficient time for these special anchors to reach the mine bases.

In the meantime the British minelaying squadron had completed its second and third operations on June 18 and June 30.

The necessary number of anchors for laying two rows of mines in Area "C" finally arrived and four of the minelayers got underway June 30, laying their cargoes of mines on the following day.

Again approximately 4 per cent of the mines exploded prematurely.

After the first excursion the probable causes which were thought might be responsible for the premature explosions were gone into and at the same time it was believed that they were largely caused by inaccuracies in assembly and testing, due to the inexperience of the personnel at the bases. The problem was not, however, allowed to rest on this conclusion. Tests were undertaken in Loch Ness and Loch Lochy to determine the accuracy of the depth taking mechanism and the ability of the mine cases to withstand the pressure when

planted at the lower level (240 feet). The depth taking performance was not particularly satisfactory, but the principal cause was discovered and remedied before the second excursion. Out of the 22 mines submerged to a depth of 300 feet in fresh water, 6 of them were crushed and leaks were discovered in 7 others. At 240 feet in fresh water no mines out of 38 planted were crushed, and a leak was discovered in only 1. It is probable, however, that the factor of safety of the mine case was so small that leaks might be started in adjacent mines by an explosion. This consideration made it desirable to increase the distance between mines from 250 feet, which was used on the first excursion, to 300 feet, which was employed on all following excursions.

The possible causes of premature explosions were many. Soluble washers which were designed to dissolve about 20 minutes after the mine had been planted were found to be very erratic, some of them dissolving in less than a minute after the mine had been planted. The antenna release mechanisms were not entirely satisfactory. Sometimes the shock of the mine striking the water was sufficient to release the floats, allowing the antennæ coils to foul the mine and fire it as soon as the soluble washer had dissolved. Leaks in the mine case could cause short circuits which would operate the firing mechanism. In the original design of the mine it had included a circuit breaker in the antennæ circuit, which prevented the mine from firing in case the antennæ fouled the mine case or the antennæ floats carried away. The production of the circuit breakers had, however, been delayed and none had been on hand for the first and second excursions. After carefully going over all the probable causes of premature explosions it was impossible to attribute them to any specific cause and it was hoped that by using the utmost care in the assembly, adjustment, and planting of the mines, the percentage of explosions would be further reduced.

After the completion of the second operation it was again necessary to await the receipt of mining material before the succeeding operation could take place. The Bureau of Ordnance had been requested by cable to ship antenna floats by a fast steamer as soon as a sufficient number could be obtained from the manufacturers, in order to allow the mining to continue with as little delay as possible. Thirty-five hundred of these floats were shipped on the *Justicia*, which arrived on July 10.

On July 6 information was received that several groups of American mines had been found on the Norwegian coast in the vicinity of Bergen. As it was most important to learn the cause of their breaking adrift, arrangements were made to send Lieut. O. W. Bagby, United States Navy, to Norway to obtain all the particulars available. His efforts were fruitless. The Norwegian Government would not permit

him to inspect the mines they had recovered and, after waiting several days, he returned to Base 18. Later information received stated that about 30 mines had been washed ashore and there were no signs of any mooring arrangements. This indicated clearly enough that the moorings had parted at the mine cases. The British had experienced similar difficulties and had found it necessary to use a spring buffer between the mooring cable and the mine case to prolong the life of their mines. Such a device would, at least, not be detrimental and might materially reduce the percentage of mines which were breaking away from their moorings so the Admiralty were asked to supply us with the necessary buffers, which was promptly done.

Some of the mines recovered by the Norwegians were disassembled and the principle of the firing mechanism obtained. The Germans probably obtained the secret of our mine shortly afterwards, but as far as can be learned, they took no defensive measures to protect their submarines while passing over the barrage.

In order to ascertain if the explosions were still continuing and if mines which had broken adrift were floating in the vicinity of the mine field, the *Patapsco* and *Patuxent* were sent out on July 9. After picking up the western end of the first excursion several additional marker buoys were dropped and the tugs then steamed along the southern side of the United States fields laid in Areas A and C. No explosions were heard nor were any floating mines observed.

The fourth British operation was carried out on July 12, again in Area C.

Preparations were made for our third operation to commence on July 14. On July 11 a cable was received from the Commander-in-Chief, Grand Fleet, that no mining was to be done to the westward of the Greenwich meridian. The excursion as originally planned was to extend from the leaving off point to the first operation completely across Area "A," thus finishing the first system of mines. This change was not serious so long as it was only temporary, although it was, of course, desirable to complete one fence of mines all the way across the North Sea as soon as possible. The question was taken up with the Admiralty by Admiral Sims and, in view of the fact that it was intended only as a temporary measure, it was acceded to.

The assembly and loading arrangements were altered, and by working night shifts it was possible for the squadron to adhere to the original date of readiness, getting underway for the third excursion on July 14. The following day 5,395 mines were laid in 4 hours and 22 minutes, the largest number so far laid in a single operation. By this time the mining installations had proved most flexible and reliable. Each layer was able to lay its entire quota of mines in one continuous string at a speed of 12½ to 13 knots.

Approximately 5 per cent of the mines exploded prematurely—a slight increase over previous performances. This time it was definitely determined that part of the explosions were caused by countermining. On previous excursions groups had gone off almost simultaneously but it was generally thought to be more or less a freak occurrence of several mines individually exploding at practically the same time or due possibly to the reverberations of an explosion which sounded like several mines individually exploding at practically the same time when it really was but one. Now, however, it was proved beyond a doubt that one mine frequently was responsible for the detonation of several others. Curiously, mines sometimes as much as half a mile away were countermined, while the adjacent mines laid only 300 feet away remained intact. Upon completion of the operation, fog was encountered making it impossible for the ships to check their position while proceeding down the Scottish coast to Cromarty Firth. The swept channel was narrow and close inshore, which added to the difficulty by denying them the prerogative of keeping well clear of the coast. Unfortunately Capt. Belknap, commanding the mine squadron, had issued an order with respect to the danger of sounding, that caused three of the commanding officers not to sound. At 4.20 a. m. July 16, while just north of Cromarty Firth, one of the escorting destroyers sheered close in to the *San Francisco* and reported that they were too close inshore. The squadron turned out, stopped and backed but before headway had been checked the *Roanoke* and the *Canonicus* had grounded. The *Canonicus* was able to back off but attempts to clear the *Roanoke* were unsuccessful. She was lightened as much as possible and came off easily on the following high tide. No damage was sustained by either vessel. The Commander Mine Force recommended no further proceedings and the matter was disposed of by Admiral Sims in a letter, in part as follows:

> The Force Commander is of the opinion that a court of inquiry should have investigated the causes for the grounding of the *Roanoke*, on July 16, 1918. It is, however, and has been, impracticable, to order officers of sufficient rank, to compose such a court; it is noted that damage to the *Roanoke* and other vessels concerned, was slight, and that their availability for duty was not impaired.
>
> In view of the foregoing, no further action will be taken by the Force Commander, and the papers in the case will be forwarded to the Navy Department for such action as may be deemed expedient.

About this time the question of the length of antennæ again arose. It will be remembered that the original design of the mine called for antennæ 100 feet long. Early in 1918, however, data became available which showed that the mine charge was insufficient to do material damage to a submarine at this distance. The

antennæ was then shortened to 70 feet. Later on further experiments showed even this distance to be too great to seriously cripple a submarine on the surface. It was therefore decided to reduce the length of the antennæ on the upper mine to 55 feet. This change had no sooner been decided on than actual experience showed it was desirable to still further reduce this length. The second week in July, a German submarine while attempting to cross the minefield on the surface struck a mine which exploded but did not do sufficient damage to prevent her reaching port. She reported her condition by radio, which was intercepted and deciphered. The Grand Fleet immediately dispatched fast vessels to attack her. She was able, however, to make sufficient speed to reach her base before this could be accomplished. Upon the representation of the Commander-in-Chief, Grand Fleet, and the desires of some of our own representatives, it was decided to further reduce the antennæ for surface mines to 35 feet, planting the mines 45 feet below the surface.

The fifth British operation was carried out on July 21 in Area "C." Several days delay was encountered before our fourth operation on account of again having to wait for mining material. The squadron was reported ready to sail July 25 but it was necessary to wait four days more for the escorting and supporting forces from the Grand Fleet. The British and American operations had recently been overlapping each other in such a manner that one squadron was out at sea while the other was loading in port. As this necessitated keeping a large part of the Grand Fleet at sea almost constantly, the Commander-in-Chief desired that we should wait until the British squadron had again loaded, so that it would only be necessary to send one force to support both squadrons.

The antennæ for the surface mines were not shortened on this excursion since the mines had already been assembled and loaded on board the layers. The squadron sailed on July 29, laying 5,399 mines the following day. The premature explosions were much more numerous than on any of the previous excursions, approximately 14 per cent of the mines going off. This was most disconcerting. Instead of the explosions decreasing as experience was gained in the assembly and laying of the mines, the percentage had been gradually increasing and then had suddenly jumped to 14 per cent on this excursion. Losses of 3 to 4 per cent could possibly be tolerated, but this latter figure was absolutely prohibitive, and the causes of the explosions had to be definitely determined and eliminated.

The same date the minelayers left their bases, Admiral Strauss, accompanied by Lieut. Noel Davis, left Base 18 to represent the

United States at an allied naval conference to be held at Malta to consider minelaying operations in the Mediterranean.

Due to the large number of premature explosions which occurred in the fourth operation, the Force Commander ordered the suspension of further minelaying operations until the cause of the explosions had been ascertained and corrected. All conceivable reasons which might be responsible were again gone over and further tests were conducted. Of these, two seemed to offer the only possibilities of solution. Circuit breakers had been used in the antennae circuits for the first time. This device consisted of a mercury cup which broke the circuit in case the antennae was not released from the mine, or if the floats were carried away allowing the antennae to drop down upon the case. In what adverse manner the circuit breaker might affect the firing device could not be imagined, still there was a possibility that it was at least partially to blame. The other cause was believed to be due to difficulties in installing the horn bushings in the mine case. Unless this was most carefully done there was danger of grounding the circuit of the firing device on the mine case which would cause the mine to fire as soon as the soluble washer had dissolved.

Believing that the difficulties could be most quickly solved by actual planting, arrangements were made for the next excursion to begin on August 8. Mines were assembled with the electric circuits to the horns disconnected, but in all other respects the same as before.

This was again a joint excursion by the British and American squadrons, the British laying surface mines in Area "C" to the southward of those laid by us on July 1. This was a departure from the original scheme by which the British were only to lay deep mines in this area, but it was in line with the recent change in policy that the surfaces should be more densely mined than the lower depths. Besides this, all our mines which had been laid in Area "C" had 70-foot antennae, which were unquestionably too long to insure the destruction of submarines on the surface.

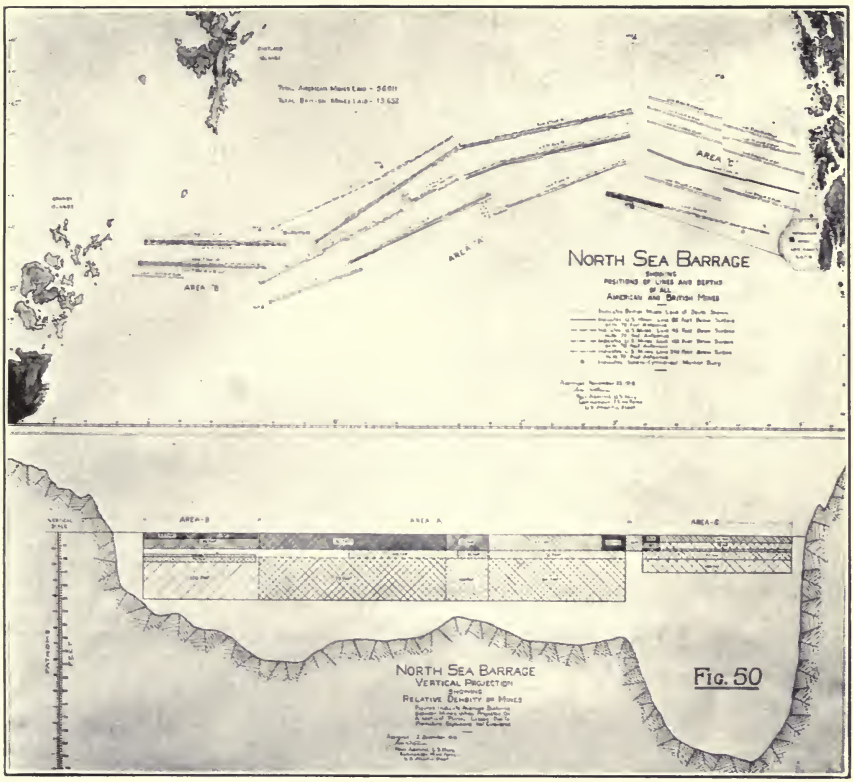
The efforts to cure the premature explosions on this excursion were found even less successful than before. After laying 1,596 mines the operation was discontinued and the squadron returned to the bases. Approximately 19 per cent of the mines had exploded.

Evidently the horn circuit could not be at fault and it must be something else. Numerous experiments were again carried out in hopes of discovering the secret of the explosions and another possible cause was developed. It was found that the rubber insulation between the copper plates on the firing device caused sulphates and sulphides to be formed with the copper which, when immersed in salt water, set up a slight current in the firing circuit in the direction necessary to operate it. Although the current was in most cases

SMOKE SCREEN MADE BY DESTROYERS TO PROTECT MINELAYING FLEET.

(Page 117.)

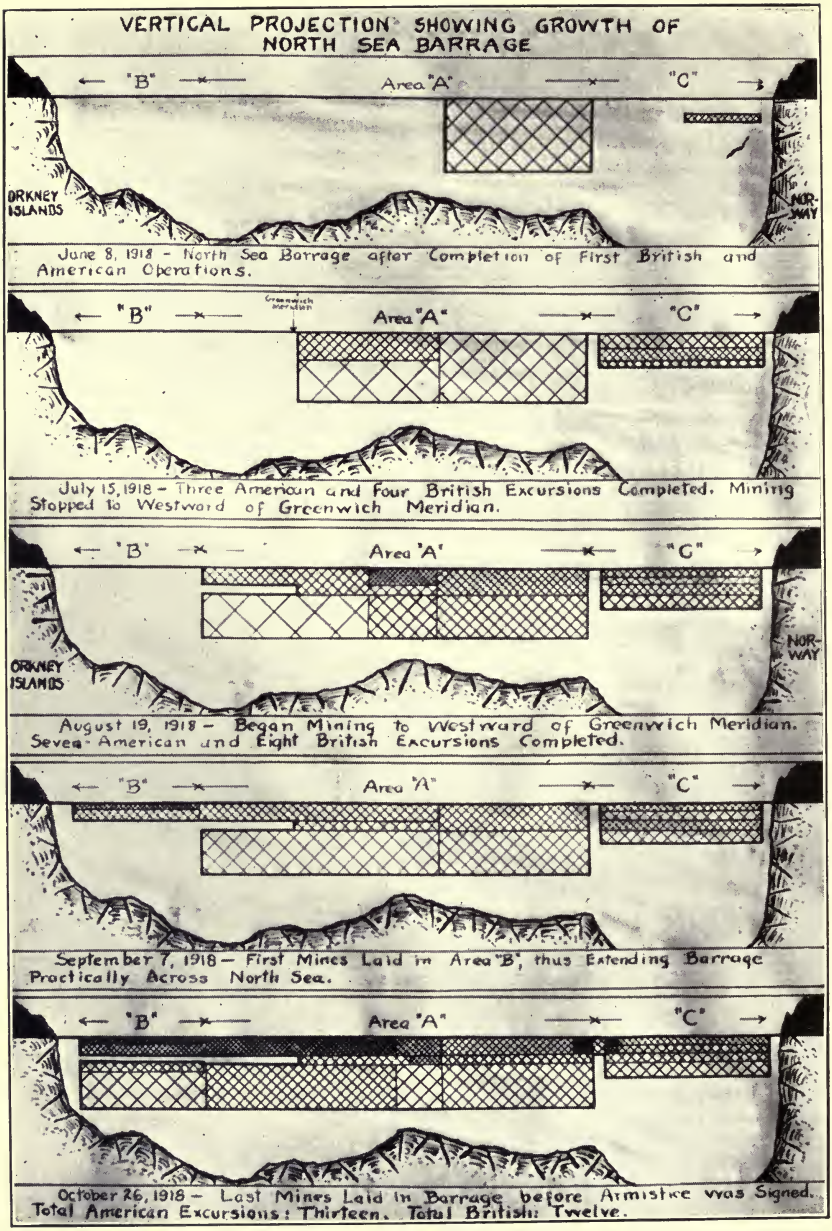
(Page 115.) MINELAYER LAYING A MINE BARRAGE, PROTECTED BY THE GUNS OF AN ACCOMPANYING BATTLESHIP.



PHOTOSTATIC CHART OF NORTH SEA BARRAGE.

1. Showing positions of lines and depths of all American and British mines.
2. Vertical projection showing relative density of mines.

(Page 122.)



PHOTOSTATIC CHART, VERTICAL PROJECTION, SHOWING THE GROWTH OF THE NORTH SEA BARRAGE.

(Page 124.)

small, there was a possibility that if it were eliminated the mines would then have sufficient stability so as not to explode after they had been planted.

In order to carry out the practical part of the experiments after the theoretical tests had been completed at the bases, the *San Francisco* proceeded to the mine field on August 12. The copper plates of the K–1 devices were carefully cleaned and circuit breakers were fitted on half of the 166 mines which were to be planted. Seven of this number exploded prematurely, four of which were due to the antennae fouling the mine cases. In order to obtain definite data in regard to countermining three mines were set to fire as soon as the soluble washers dissolved. Each of these caused one additional mine to explode. A depth charge was also dropped in the vicinity of the field, which caused six mines to go off.

The improvement obtained in this test was sufficient to enable minelaying to be resumed after cleaning the copper plates on all mines. It was further decided to omit the circuit breakers, as they were additional complications of unknown value. The copper horns of the mines were also shortened to mere points to reduce the possibility of the antennae becoming hooked around them.

The squadron sailed on the sixth excursion on August 18, and the minelaying was completed on the 19th. The British squadron proceeded at the same time to complete their lines of surface mines in Area "C." Twelve per cent of our mines exploded prematurely. The majority of these were due to countermining. The real cause of the premature firing evidently had not yet been discovered, but the improvement obtained was sufficiently encouraging to permit another attempt to be made.

On August 5 the Commander-in-Chief Grand Fleet lifted restrictions he had placed on mining to the westward of the Greenwich meridian. The next excursion was correspondingly planned to complete the first fence of mines across Area "A."

Admiral Strauss returned from the Malta conference on August 22. After the sixth excursion another probable cause of the premature firing was discovered, which proved to be the final solution of the difficulties. The first lots of firing devices shipped to the bases were adjusted to fire at a voltage between 25 and 40 millivolts. The Bureau of Ordnance decided, from experiments conducted in the United States, that this voltage was unnecessarily high and reduced it so that the mines would fire between 10 and 25 millivolts. It was not known when this later type of firing device first began to be installed. The original type was undoubtedly used on the first three excursions, when a comparatively low percentage of the mines exploded. After that, it was probable that the majority of the mines

were assembled with the firing devices which had been adjusted to fire at the lower voltage.

It was therefore decided that on the seventh excursion the first 600 mines planted should be adjusted to fire between 20 and 35 millivolts; then, if the observations on this part of the field indicated sufficient improvement, this adjustment should be used on subsequent excursions.

The squadron got under way August 26 and stood out toward the mine field. The *Saranac* broke down shortly after leaving the base and had to return to Inverness with her full cargo of mines. The remaining nine ships, however, continued and carried out the operation. Unfortunately dense fog was encountered practically throughout the operation; so thick at times that it was impossible for the vessels to see the next ship abeam, distant only 500 yards. These conditions made observations extremely difficult for the *Patapsco* and *Patuxent*, which were sent out with the squadron to follow astern while planting was in progress and count the explosions to determine the percentage which occurred. From the data obtained from the minelayers and the tugs it appeared that only about 3 per cent of the first mines exploded prematurely. In the remainder of the field, which had the low-voltage regulation, approximately 12 per cent went off.

The adjustment of the firing device was undoubtedly the solution we had sought for, but in order to test it further and to complete the deficiency in this field caused by the breakdown of the *Saranac*, the *Shawmut*, and *Aroostook* were loaded with mines adjusted to fire between 20 and 35 millivolts and sent out on August 30. Of the 600 mines they planted only 3 per cent exploded. This was the first opportunity we had had to use these two vessels for their originally intended purpose; that is, as a fast wing to the mining squadron. Both ships proceeded to the field and planted their full quotas at a speed of 17 knots with no difficulty. They could plant as easily at their maximum speed as they could at 12 knots.

This final solution of the premature explosions was a great relief. It explained, in addition, the probable reason for countermining. The tests conducted to ascertain the effect of the copper sulphate deposits on the plates of the firing device showed that as much as 10 millivolts could be generated. This was sufficient to rotate the armature of the firing device through a considerable portion of its arc so that a slight additional shock, which might readily be caused by the explosion of a nearby mine, would be sufficient to shake the firing ball from its cup and detonate the mine. By increasing the tension of the hair spring on the armature, the voltage necessary to fire a mine could be raised to the desired amount.

In the latter part of August information was received that another enemy submarine was damaged while attempting to cross the barrage

and had been compelled to return to its base on the surface. These repeated instances of submarines deprived of their principal means of defense, pointed more strongly than ever to the necessity of having patrol vessels stationed at intervals along the barrage to attack submarines which had encountered mines but had not been completely destroyed.

The question of mining Area "B" again came up, and a decision was finally reached to mine it with both surface mines and deep mines. The commander in chief, Grand Fleet, however, objected to mining completely up to the Orkney Islands, and it was decided that a gate 10 miles in width would be left which should be closed later when conditions indicated this step to be necessary.

The mines which had been laid in this area by the British in March, 1918, had in the meantime been swept up. The British had also placed a series of mine nets to the southward of Area "B," extending part of the way between the western end of Area "A" and Duncansby Head. These had not proved successful and were also removed before the mining in Area "B" was resumed.

The eighth excursion was intended as a surprise excursion. Neutral nations had not been notified that Area "B" was dangerous to shipping, and with this knowledge, enemy submarines were constantly passing through it on their way to the Atlantic. It was accordingly decided not to notify the area but to secretly route all shipping so as to avoid it, with the hope that submarines might still attempt to use it after it had been mined. In order to prevent the enemy observing the mining while it was in progress, an elaborate patrol was arranged, beginning the day before the operation and continuing until after its completion.

British and American mining squadrons rendezvoused off the Orkney Islands on September 7 and proceeded to carry out the operation. We laid six lines of surface mines across Area "B" while the British laid one line of surface mines parallel to ours. This was really the first joint operation carried out by the British and American squadrons. On several previous occasions both squadrons had been at sea at the same time, but had not been working side by side, so as to necessitate appointing one officer to command the expedition. On this occasion Admiral Strauss was designated to take general charge of both squadrons while mining was in progress.

In spite of the high voltage adjustment of the firing devices, 13 per cent of the mines exploded. About five-sixths of this number were due to countermining, indicating that the mines were still too sensitive and that the voltage must be still further increased. Tests that had been made indicated that contact of the antennæ with the hull of the ship invariably gave voltages about 100 millivolts and it was therefore considered entirely safe to further increase the adjustment

of the firing device to operate between 30 and 45 millivolts. This was done for all subsequent excursions.

An interesting sidelight on the activities of the mine force were the tests and experiments which were almost constantly in progress. Besides the difficulties encountered in solving the problem of premature explosions, numerous other questions arose in connection with the new American mine. The facilities at hand were ideal for mining experiments. The chain of lakes forming the principal part of the Caledonian Canal, which terminated at Base 18, offered smooth water with depths varying up to 800 feet, which corresponded to the maximum depth encountered in the North Sea barrage. The only drawback was that the water was fresh instead of salt. During July the British had conducted a series of experiments to ascertain the accuracy with which their mines took their prescribed depth. The results were not entirely satisfactory, and since our mine anchor had been largely copied from the one they were using, it was also probable that ours were not behaving as designed. Tests were carried out in Loch Lochy during the first week in September when 50 mines were planted with anchors adjusted to moor the mine 45 feet below the surface. The average depth actually taken was 44.6 feet. The shallowest mine was 39.2 feet, and the deepest one at 48.7 feet. The results were entirely satisfactory and were all that could be expected.

All the mines which had thus far been laid in Area "B" were surface mines, and since this was still the weakest part of the barrage it was decided that the following excursion should also be placed in this area, laying two rows of mines at each of the three standard depths.

A delay of nine days was occasioned waiting on the British mining squadron, since it was desired that both the British and American squadrons should lay their mines on the same date in order to reduce the possibility of the enemy observing mining operations in this area. Delays of this nature were most serious. It was realized that mine-laying operations would be interfered with if not altogether stopped during the winter months on account of the severity and frequency of the storms in the North Sea. It was also extremely desirable to complete the barrage at the earliest possible date in order that operations in the Mediterranean might be undertaken.

The work of assembling mines at the bases, refueling the ships, and embarking new loads of mines had reached such a stage of efficiency that it was possible to reduce the length of time that it was necessary for the ships to remain in port to two days. The vessels were ordinarily away from the bases two or three days, thus making it possible to complete an operation every four or five days. At the same time mines were being shipped at a faster rate from the United States in anticipation of the speed with which they could be laid. Delays,

therefore, caused most serious complications at the bases on account of the difficulty of stowing the material in the limited spaces provided. Another phase which should not be overlooked was the effect on the morale of the personnel aboard the minelayers. It was always necessary to load the layers as soon as possible after their return to port since delays could seldom be foreseen. This resulted in the vessels remaining in harbor with cargoes of mines on board for a considerable period of time. This caused serious inconvenience to the personnel since practically all of the living space on board was occupied by mines, making it necessary for the men to sleep on deck between the tracks or wherever it was possible to find sufficient space to spread a hammock. Messing arrangements, as well as nearly all of the other accommodations existing on board ship, were badly interfered with. These delays became more frequent and of longer duration as the completion of the barrage drew near. Sometimes it was due to having to wait while the British squadron was being loaded, but more frequently was attributed to movements of the Grand Fleet, making it impossible to supply the necessary destroyers to act as our escort. Had it been possible to obtain sufficient of our own destroyers for this purpose it would have enabled the barrage to have been completed by approximately the 1st of October.

In the early morning of September 20, while the United States mining squadron was on its way to the mine field to carry out the ninth excursion a submarine was sighted off Stronsay Firth. She was immediately attacked with depth charges by the escorting destroyers, and at the same time a smoke screen was put out by both the escort and the minelayers. Shortly afterwards she was again sighted just ahead of the *San Francisco* and was again attacked. The behavior of the submarine was most unusual. Although both times she was sighted she was in good position and at a comparatively close range, no attempt was made to fire a torpedo. It is highly probable that she had been sent to this position to the southwestward of the lines of mines which had shortly before been laid in Area B, in order that she might make observations of the positions in which mines were being laid in this area.

The squadron proceeded through Westray Firth and thence to a position about 6 miles to the northward of the western end of the field which was laid on the 7th of September, where the mining began. In this excursion, 5,520 mines were laid in 3 hours and 50 minutes—the record number that has ever been laid by a minelaying force in a single operation. At the same time the British squadron laid 1,300 mines in a single line parallel and to the northward of those laid by us. Rear Admiral Strauss, on board the *San Francisco*, was in command of the American minelayers. Rear Admiral Clinton-Baker, R. N., commanded the combined forces.

During the minelaying, when about midway between the ends of the previous field which had been laid in Area "B," one of the escorting destroyers sighted the body of a dead sailor floating in the water. He was recognized to be a German by the type of the life preserver he wore. Since no engagements with the enemy had occurred within miles of this position, it is extremely probable that an enemy submarine had been destroyed by one of the mines which had been laid on September 7.

The reduction of premature explosions on this excursion was a marked improvement, being between 5 and 6 per cent, as compared with 13 per cent on the previous operation. The firing devices had been adjusted to operate between 30 and 45 millivolts, and this regulation could not readily be increased on account of the construction of the mechanism. It was perhaps as well that it should not be further raised as the mine might be possibly made too insensitive to operate when a poor contact was made by the antennæ.

After completing the ninth excursion, work was resumed in Area "A." On September 27, 5,450 mines were laid, slightly over 4 per cent of which exploded prematurely. Only nine of the mine layers took part in this operation.

On account of the great depths of water in which it would be necessary to lay mines in the Mediterranean, it was necessary to develop a special type of mine. A satisfactory design had been evolved by the Bureau of Ordnance, but it was essential to conduct a series of practical tests before beginning the manufacture. No vessel was available in the United States for this purpose, so the *Baltimore* was ordered home to carry out the required experiments. She proceeded as far as Pentland Firth in company with the squadron on their way to the mine field for the tenth excursion, where she was detached to Scapa Flow to obtain routing instructions across the Atlantic from the Commander-in-Chief Grand Fleet.

The eleventh operation was carried out on October 4, again in Area A, and approximately 6 per cent of the mines exploded prematurely. Losses up to this amount had, however, come to be accepted as normal for this type of mine. The Bureau of Ordnance also considered this figure a reasonable loss on account of the various defects which are invariably encountered in the production of material in such vast quantities.

Since the operation in the Mediterranean would probably have kept the mine force engaged until well into the summer of 1919, it was considered advisable to have the minelayers docked prior to their departure for those waters, where such facilities would be extremely limited. After the completion of the eleventh excursion the *Shawmut* and *Aroostook* were detached from the squadron and proceeded to Newcastle-on-Tyne for this purpose. It was intended to send two

vessels there after each operation, having them return in time to take part in the second following excursion. Permission was obtained for the ships' crews to do the work in connection with scraping and painting the ships' bottoms—an arrangement which had been found to very materially shorten the time required for docking.

With the mining of Area "B," the problem of enemy submarines gaining access to the Atlantic became serious. Several submarines had encountered mines in the barrage, but had managed to reach their bases bearing material evidence of the existence of the barrier. It was only natural, therefore, that the enemy should look about for whatever means remained of reaching the Atlantic without risking passage across the mine fields. Small submarines occasionally successfully ran the blockade at the Dover Channel, but this was apparently not attempted by the larger boats. Pentland Firth and the 10-mile gate to the eastward of the Orkneys were heavily patrolled. Submarines evidently would not risk passage through Pentland Firth while submerged on account of the dangerous currents. The only remaining passage was through Norwegian territorial waters. Although Norway had issued a proclamation that belligerent submarines using her waters for this purpose would be fired upon, this risk seemed less than any of the others and there was no apparent hesitancy in using it. One enemy submarine, while passing through these waters even went so far as to fire on a Norwegian vessel. These repeated violations resulted in a statement on September 29 by the Norwegian Government that mines would be laid in the vicinity of Udsire Island in order to prevent belligerent vessels using her territorial waters for purposes contrary to the provisions of international law. This mining is understood to have been completed by them about the 7th of October and had the effect of completing the barrage from the end of Area "C" to the Norwegian coast.

On October 11 the British squadron laid two partial rows of surface mines in the southwestern portion of Area "B." These proved to be the last mines laid by them in the North Sea barrage prior to the armistice a month later.

The U. S. mining squadron completed the twelfth excursion on the 13th of October, losing 4 per cent by premature explosions. The *Roanoke* and *Canandaigua* proceeded to Newcastle for docking upon the completion of the operation.

Eight days' delay were encountered before the thirteenth and last operation could begin. On account of the sequence of the British and American operations in Areas "A" and "C," it had been impractical to extend the mine fields so as to overlap each other. This left a gap between the two areas approximately 6 miles wide. In order to close this the next excursion was planned to consist of six rows of

surface mines to the southward of the gap, continuing with two rows into Area "C," so as to complete the four rows which the United States had agreed to lay in this Area.

The first of the winter weather was encountered in this operation, when it was necessary for the squadron to wait one day after having reached the mine field before the sea moderated sufficiently to enable the mines to be laid. Even then the ships were rolling as much as 20° to 30° on each side of the vertical. This provided an excellent test of the mining installations with the result that no difficulties were encountered by any of the ships, either in the stowing of their mines or in the actual planting under such severe conditions. The operation was completed October 26, having laid 3,760 mines, of which slightly over 4 per cent were lost by premature explosions.

Although the U. S. mining squadron was again ready for the next excursion by October 30, it was necessary to wait until the British squadron had completed the operation which they had planned before escort could be furnished us. Reliable information indicated that enemy submarines were crossing the eastern portion of Area A, and the British had decided to lay surface mines in this position to the southward of those laid on our first excursion so as to strengthen this part of the field which was the least effectively mined part of the area. Weather conditions, however, prevented them from going out for several days, and, in the meantime, the series of events during the latter part of October and the 1st of November brought the end of the war so plainly in view that further mining would have been an unnecessary waste of time, effort, and material. The British squadron did not carry out their contemplated operation, nor likewise did we. With the signing of the armistice on November 11 with Germany—the perpetrator of ruthless submarine warfare against both allied and neutral commerce—came the end of building the North Sea mine barrage.

SUMMARY OF U.S. MINING OPERATIONS IN NORTH SEA BARRAGE

Excursion No.	Date Ready	Date Mines Laid	Days Delay	Cause of Delay	Number of Mines Laid	Types and Numbers	Type of Floats	Voltage Adjustment	Washer	Primary Explosions	Counter-mining	Total Explosions	% Explosions	Number Explosions within 300 yds. ships	Premature Releases of Floats	Floaters	Sinkers	Last Explosion Heard: Distance Miles	Last Explosion Heard: Hrs. after Planting Ceased	Remarks
1	6 June 1918	8 June	1	Waiting for escort	3385	[illegible] 1181, [illegible] 1138, [illegible] 1026	D4 2264, D5 1121	25-40 m.	sugar	90	10	100	5	15	—	—	5	12	1.3	Planting interval 250 feet. All installations functioned satisfactorily. Anchors functioned satisfactorily as indicated by observations of release and sinking of mine. H.M.T. [illegible] Castle reported 22 explosions [illegible]
2	30 June 1918	1 July	0	—	2220	70-80-400 2220	D5 2220	25-40	sugar	90	10	100	4.5	18	None 21	—	None 6	16	4.6	Planting interval increased to 300 feet. Mines assembled [illegible] exploded much less frequently than those [illegible] [illegible]
3	14 July	15 July	0	—	5395	70-80-400 2240, [illegible] 1078, [illegible] 1037	D4 2840, D5 2555	25-40, 10-25	sugar	214	50	264	5	25	estimated 150	9	15	16	1.5	Laying interval reduced to 250 feet last six miles only. Anchors installed at base as usual but inspected before laying and removed as necessary. British trawlers reported 37 explosions next 4 days after laying.
4	25 July	30 July	4	Waiting on British Mine Force	5399	[illegible] 2660, [illegible] 1050, [illegible] 1079	D4 2597, D5 2800	10-25, 25-40	sugar	386	370	756	14	20	estimated 110	12	9	22	2.5	Circuit breakers used and soluble washers placed in as bases for first time.
5	8 Aug.	9 Aug.	0	—	1896	[illegible]	D4 [illegible], D5 [illegible]	10-25, 25-40	Black Hawk Salt	83	222	305	14	20	40	4	4	15	2.5	Planting discontinued after 1896 mines due excessive explosions. [illegible] Circuit breakers used. Canandaigua reported 34 floats remained afloat.
6	18 Aug	19 Aug	0	—	3200	[illegible]	D4 [illegible], D5 [illegible]	10-25	salt	160	224	384	12	14	90	4	15	16	1.5	Plates cleaned. [illegible]
7	26 Aug.	27, 31 Aug	1	"Destroyers and support not available" C-in-C. G.F.	5400	[illegible]	D4 3160, D5 2240	[illegible] 10-25	salt	Ex. 1 230, Ex. 2 —	360, —	590, 17	12, 3	15	145, 34	1, 0	7, 0	15	1.5	Higher voltage on 400 mines planted first. [illegible]
8	6 Sept	7 Sept	0	—	4920	[illegible]	D4 4920	20-35	salt	167	463	630	13	25	175	8	11	12	1.5	Baltimore and Aroostook absent. Planted in Area B. Most explosions distant [illegible]
9	10 Sept	19 Sept	9	Waiting on British Mine Force	5520	[illegible]	D4 3680, D6 1840	30-45	salt	130	190	320	6	8	108	6	3	—	2	Deko floats, D6 used for first time. C.M.S.F. "One or two explosions were noted [illegible]
10	25 Sept	27 Sept	1	"Fleet movements."	5450	[illegible]	D4 2180, D5 1756, D6 1550	30-45	salt	135	99	234	4	1	135	5	7	—	5	Baltimore detached to U.S. just prior this excursion. [illegible] Plates partly cleaned.
11	2 Oct.	4 Oct.	1	"Fleet movements."	5450	[illegible]	D4 [illegible], D5 [illegible], D6 [illegible]	30-45	salt	165	160	325	6	2	237	10	15	—	9	Shawmut observed from 3 miles astern other ships, reported 6% explosions. [illegible] Correct percentage probably 6%. Sea rougher than usual. First explosion 25 min after planting began. [illegible]
12	9 Oct.	13 Oct.	3	Destroyers not available C-in-C. G.F.	4750	[illegible]	D4 2945, D6 1805	30-45	salt	100	92	192	4	1	192	17	14	23	9	Shawmut and Aroostook absent for docking. [illegible] All floats remained on surface; in eleven cases both floats remained afloat."
13	17 Oct.	26 Oct	8	"On account of general situation destroyers not available" C-in-C.	3760	[illegible]	D6 3776	30-45	salt	75	90	165	4.5	1	153	5	7	—	3	Roanoke and Canandaigua absent. All upper level mines. Delayed 37 hours by rough weather. All ships reported tracks and other mining installations withstood weather satisfactorily. [illegible]
San Francisco Experiment	12 Aug	13 Aug	0	—	166	[illegible]	D4 66, D5 100	10-25	salt	6	4	10	6	—	7	0	3	—	—	Cleaned plates used for first time. 50% with circuit breakers.

SUMMARY OF UNITED STATES MINING OPERATIONS IN THE NORTH SEA BARRAGE. (Page 121.)

Chapter XVII.

FINAL STATUS OF BARRAGE AND RESULTS OBTAINED.

On November 11, 1918, when hostilities ceased upon the signing of the armistice, the status of the northern barrage, as set forth in an allied naval council annual report, dated December 16, 1918, was as follows:

1. The northern barrage extends from Norwegian territorial waters to within 10 miles of the Orkney Islands, and lies in the area contained by the following positions:

60° 0′ N., 4° 54¾′ E.
60° 21′ N., 3° 10′ E.
59° 20′ N., 0° 50′ W.
59° 20′ N., 2° 5′ W.
58° 50′ N., 2° 27′ W.
58° 50′ N., 0° 50′ W.
59° 29′ N., 3° 10′ E.
59° 12½′ N., 4° 49′ E.

2. The barrage has been divided into three areas, "A," "B," and "C." Area "C" extends from Norwegian territorial waters to the meridian of 3° 10′ E. Area "A" extends from this meridian to 0°-50′ W. and Area "B" from the western extremity of Area "A" to within 10 miles of the Orkneys.

3. Mine laying operations were commenced in March, 1918, by Great Britain, and in June, 1918, by the United States of America, British and American mines being used, and up to November 11 a total of 56,760 United States and 16,300 British mines have been laid.

4. The original intention was that the United States minelayers should lay the mines in Area "A" and the British minelayers in Areas "B" and "C," and this arrangement has in the main been adhered to, but a certain number of United States mines have also been laid in Areas "B" and "C." This was done in order the more effectively to deal with the submarine situation at the moment, and to make the best use of the greater minelaying capacity of the United States minelayers.

5. The completion of the barrage within the Norwegian territorial waters has been effected by Norway herself.

In July, 1918, conclusive evidence was obtained that German submarines were habitually using Norwegian territorial waters.

Representations were made by the British Government to the Norwegian Government that the only effectual way of securing the observance by Germany of the Norwegian royal decree was for Norway either to mine these waters herself or to allow the allied and United States Governments. After protracted negotiations, during which evidence as to the identity of submarines reported on various dates to have been seen in Norwegian territorial waters was furnished to the Norwegian Government, a note was received from the Norwegian Government by the allied and associated Governments on the 28th September protesting against the violation of Norwegian regulations by a British submarine (in a case which had been previously admitted by Great Britain) and stating that in view of the numerous cases of infringement of her territorial waters by submarines which had been established with certainty, it had been decided to lay mines in certain localities.

6. On September 29, 1918, an official announcement appeared in the leading Norwegian Government organ to the effect that mines would be laid in Norwegian waters between latitudes 59° 8′ N. and 59° 25′ N., and to the westward of longitude 5° 10′ E., and that these waters would be closed for general traffic from October 7, 1918.

AREA "A."

7. The depth of water in this area is from 50 to 80 fathoms. The approved mine fields in this area will, when completed, consist generally of—

Nine lines of United States mines dangerous to surface craft and to submarines at periscope depth.

Three lines of United States mines at a depth of 160 feet, the mines having a dangerous area (above the mines) of 70 feet.

Three lines of United States mines, at a depth of 240 feet, with a similar dangerous area.

Three more operations were required to complete the approved minelaying in this area. Any reinforcement of the mine fields in Area A would depend on the submarine situation at the time.

AREA "B."

8. The depth of water is from 40 to 75 fathoms. At the present time the following lines of mines have been laid across the area:

One line of British mines dangerous to surface craft;

One line of British mines, at 95 feet deep;

Eight lines of United States mines, dangerous to surface craft and to submarines at periscope depth.

Two lines of United States mines, at 160 feet deep, having a dangerous area (above the mines) of 70 feet.

Two lines of United States mines, at a depth of 240 feet, with a similar dangerous area.

Two further lines of British mines have been commenced across the area. The submarine situation will determine any future action in this area.

AREA "C."

9. The depth of water is from 65 to 160 fathoms. At the present time the following lines of mines have been laid across Area "C":

Two lines of British mines, dangerous to surface craft.

Two lines of British mines, at 65 feet deep.

Two lines of British mines, at 95 feet deep.

Two lines of British mines, at 125 feet deep.

Four lines of United States mines, dangerous to surface craft and to submarines at periscope depth.

Six lines of United States mines, dangerous to surface craft and to submarines at periscope depth have been laid across the junction line between Areas "A" and "C."

Any further mining in Area "C" will depend upon the submarine situation at the time.

GATES.

10. There are no gates in the barrage, the only free passage through being the 10-mile gap at its western extremity, which, however, is not used more than is absolutely necessary.

PATROL.

11. The barrage is not patrolled.

Rear Admiral Strauss has summed up the final status of the operation and the results obtained from it is as follows:

Had it been possible to carry out minelaying operations as fast as the necessary mining material was received and assembled, the American portion of the North Sea barrage could have been completed by the latter part of September, 1918. The frequent delays, especially during the latter part of the work, which were principally due to the necessity of awaiting for escort to be supplied by the Grand Fleet, or for the British mine squadron to complete its preparations so as to be able to go out at the same time, prevented the barrage from being completed prior to the signing of the armistice with Germany on November 11.

In all, 70,263 mines were laid, 56,611 being American mines, laid by the United States Mining Squadron. Area "A," which was originally allotted as the United States portion of the barrage, was completed except for 6,400 mines more, which could have been laid in approximately 10 days. Besides mining Area "A" exclusively, the United

States mining squadron had laid 10,440 mines in Area "B," and 5,980 mines in Area "C." Thus it will be seen that in addition to mining the part of the barrage originally assigned to the United States Government, we had in addition laid more mines in the British Areas "B" and "C" than they themselves had put down. One more small excursion in Area "B" by the United States mine force would have given it the same density of American mines as Area "A." Area "C" was the weakest portion of the barrage. The British had originally agreed to mine this area only to a depth of 200 feet, but were only able to complete the work to a depth of 125 feet. This figure was just one-half the effective depth of the remainder of the barrage.

Until the animosity incident to warfare has disappeared and the freedom of dicussion of war-time secrets can be attained, it will be impossible to accurately determine the actual results achieved by the North Sea barrage. Such information as has been possible to collect bears witness to its efficacy notwithstanding the short time the barrage was in operation.

After the first two American excursions had been completed, two enemy submarines were damaged in attempting to cross Area "C." The first, the *U–86*, was damaged on July 9 while passing homeward, reaching port successfully and bearing tangible proof that the North Sea barrage was a reality and not a threat. The other, the *UB–22*, was to have passed, but nothing has been heard from her since. The enemy of course immediately routed his submarines through Area "B," which had not been proclaimed, or through Norwegian territorial waters. On August 10, *U–113* was damaged in the barrage on an outward bound trip and was forced to turn back. The surprise mining in Area "B" on September 7 obtained immediate results. It will be remembered that when it was decided to place mines in this area no notification was given to neutral nations that it would be dangerous to navigation. Instead, a heavy patrol was placed around the area to guard it and keep down enemy submarines while mines were being laid. Just prior to the mining operations a large convoy was routed across this area in order to deceive enemy submarines which might possibly have seen the convoy, and thus lead the enemy to believe that this area was to be maintained free of mines. On September 8, the day following that on which the mines were laid, the *U–92* was sunk in this area, while another submarine was so severely damaged that it was forced to return to its base immediately. This occurred while the submarine was outward bound. Rather than risk a passage again through the same waters, she proceeded to Area "A," recrossing the barrage in that position without further damage.

After this it appeared that passages were attempted directly across Area "A," which, due to the United States participating in the mining of Areas "C" and "B," was comparatively poorly mined. The tenth,

eleventh, and twelfth excursions, however, during the latter part of September and the first part of October added a great deal to the effectiveness of Area "A," so that the loss of *U–156* on September 25, and *U–123* on October 18 can most certainly be attributed to this area.

With the information at present available, it appears that a total of six submarines were destroyed in the barrage and possibly an equal number were severely damaged. On account of the difficulty of obtaining accurate information, such a short time after the armistice was signed, it is highly probable that subsequent data will show even greater damage to have been done.

It is well to remember that a mine barrage of this nature can never be an absolute barrier possessing 100 per cent efficiency. On account of the necessity of laying the mines at a distance of approximately 300 feet apart in order to reduce the possibility of countermining, it would always be possible for a submarine with a beam of approximately 30 feet to successfully cross such a barrier no matter how many parallel lines of mines may be laid. The danger in crossing, of course, increases with the number of rows of mines but not in direct proportion. The object, then, in constructing a barrage must be to make the danger incurred by the passage of a vessel sufficiently great to prevent submarines from taking the risk involved. The American portion of the barrage was designed to offer the following resistances to the passage of submarines:

A vessel passing on the surface or submerged above a depth of 50 feet stood one chance in three of making a successful passage; submarines passing submerged between depths of 50 feet and 250 feet had approximately two chances out of three of passing the barrage without encountering a mine.

The object of making the passage across the surface barrage more dangerous than at the lower levels was largely psychological, for, even though a submarine which was forced to cross the barrage might know that the danger on the surface was the greatest, the moral factors involved were usually sufficient to induce them to accept the greater hazard on the surface rather than face the danger of striking a mine while submerged.

In connection with the enemy's attitude toward anti-submarine measures taken by the Allies, it is interesting to note the statement of a captured German submarine commander who had had considerable experience on that particular type of vessel. He expressed the opinion that of all the anti-submarine measures which had been taken, mines were by far the most dreaded by the German submarine personnel, principally because there was nothing to indicate their presence. Also, because the quality of allied mines had recently been improved in a most unpleasant manner, the former practice of fish-

ing them up and taking them home for conversion into punch bowls for submarine messes had now been entirely abandoned, he said.

One feature of the barrage which offered several possibilities but was never more than partially put into operation was the question of patrols to guard the mine field to force submarines into the deep mines and destroy those which had not been completely disabled. This measure had been argued for from the very beginning although no definite agreements were ever reached. The first arrangement was that Areas "B" and "C" should be deep mined only and that the surface should be guarded with patrols. Area "B" was not mined, however, until comparatively late in the work on the barrage and during this time was only indifferently patrolled, thus affording a comparatively safe passage for enemy submarines through this area. The United States Government had been asked to lay two rows of surface mines in Area "C" early in the history of active operations and this had been done on July 1. Two lines of mines, however, form a very ineffective barrier and patrols in this area would have been of the greatest assistance, not only in driving submarines into the lower level mines, which were more closely spaced, but also in preventing submarines from using Norwegian territorial waters to get by the barrage. This latter measure could have been effected by hydrophone vessels lying outside the Norwegian territorial waters where enemy submarines could easily have been detected when attempting such a passage. The question of patrols, especially for catching crippled submarines after it became known that many of them were not disabled when exploding a mine at a distance of 70 feet, arose continuously but on account of the tremendous demands for such vessels both for antisubmarine work in other waters and for escorting coastwise convoys, it was impossible to obtain any vessels for this purpose.

Although the enemy undoubtedly obtained the secret of the American mine shortly after the first mines were washed ashore and recovered in Norway in the early part of July, it is interesting to note that apparently no attempt was made to fit their submarines with protective devices which would have enabled them to pass safely through the American mine fields. Such a device, although it was unknown until after the armistice, was readily devised when the necessity arose for protecting vessels which would be employed in clearing the North Sea of mines after the end of the war.

Information had also been received indicating that the Germans had built special vessels called mine barrier breakers of a practically unsinkable character so that they could be used to clear passages through mine fields. Evidently none of these vessels attempted operations in the North Sea barrage.

The mine as a weapon of nautical warfare now presents greater possibilities than ever before. The United States in less than one year was able to construct a squadron of minelayers and produce sufficient mines to keep them constantly employed, laying on each excursion in less than four hours more mines than the United States had ever possessed prior to her entry into this great war. Too much credit can not be given to those who designed the mine. Clever, simple, and effective, this mine proved, perhaps, the most efficient single weapon against the enemy's submarines. Equally as remarkable as the invention of the mine itself was the development and production by the Bureau of Ordnance. Any complicated instrument of this nature, ordinarily, requires years of experiments and modifications before it finally becomes sufficiently satisfactory and reliable to allow it to be used. Time, however, was the supreme factor. Every minute counted in order to save the merchant shipping and the wise forethought and judgment of those to whom the production of the mine was entrusted should go down in history as one of the most worthy achievements of the war. Minor defects and difficulties, of course, were encountered in the actual operation and handling of the mines, but these were also met and solved on the spot by the United States mine force.

Minelaying, like the havoc wrought upon the battle fields by the destruction of property, leaves its effects to be felt after peace is obtained. Thousands upon thousands of mines have been laid in European waters, a major portion of the work being concentrated in the North Sea barrage. With the cessation of hostilities and the resumption of free shipping these mines constitute an ever present danger to the vessels on the seas. Many of them break adrift and, carried by the wind and tide, often appear in waters which were thought to be clear of mines. One of the first steps after the armistice was to divide the work of clearing the seas among the various nations involved. At an allied naval conference, the United States volunteered to remove all mines which she had laid and arrangements were immediately taken in hand to carry out this work. A method of sweeping this peculiar mine, together with the development and the organization of the force required, had been completed and actual sweeping operations were commenced four months after the armistice was signed.

Chapter XVIII.

CONTEMPLATED MINING OPERATIONS IN THE MEDITERRANEAN.

The activities of enemy submarines in the Mediterranean had been increasing at an alarming rate until in the early part of 1918 it was realized that an energetic antisubmarine campaign must be made in order to cut down the loss of tonnage in this area. The allied military operations in Saloniki, Mesopotamia, and Egypt were supplied almost entirely by vessels whose routes lay through the Mediterranean. In addition to this, considerable shipping was carried on between Tunis, Italy, and France. During the summer of 1918 there was an average of 190 merchant vessels and transports, aggregating a total of 720,000 tons, at sea each day. Most of this shipping was forced at some place or other in the Mediterranean to pass through comparatively restricted channels, offering ideal conditions for submarine attacks. Submarine operations were also greatly enhanced by the lack of escort—approximately 22 per cent was inadequately escorted.

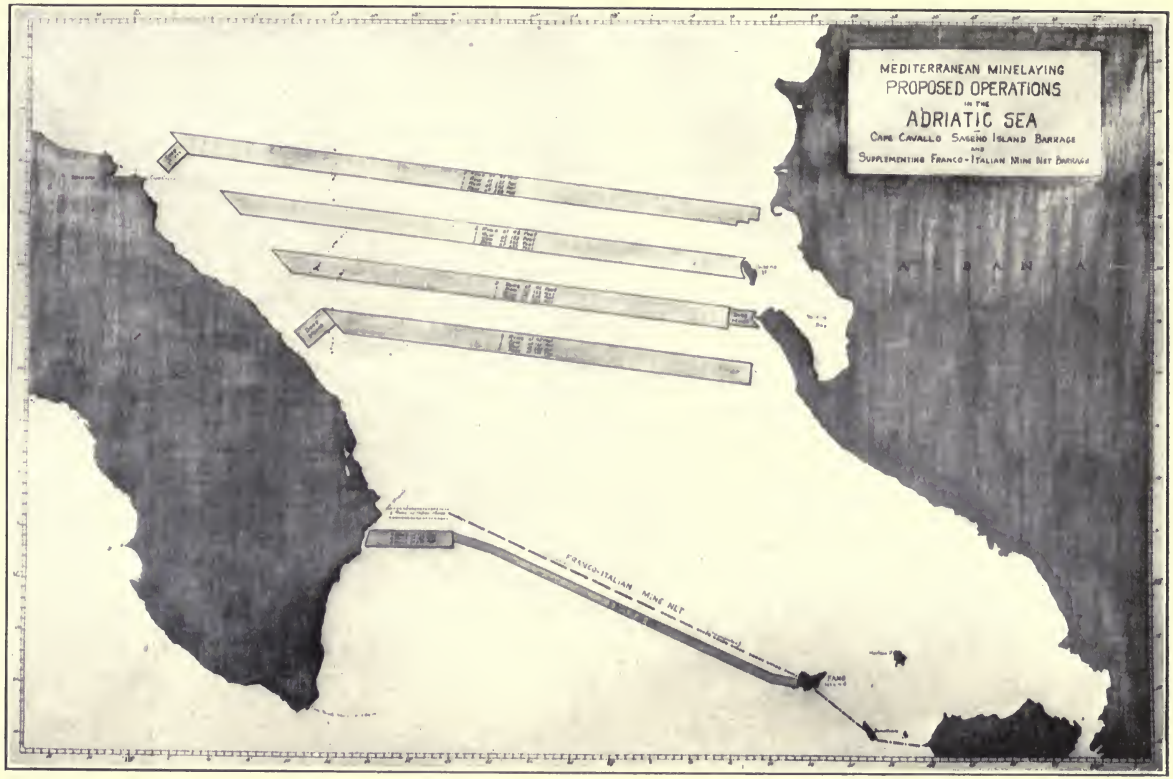
The enemy had gradually increased the number of submarines in the Mediterranean by sending them from Germany around through the Straits of Gibraltar to be based on Mediterranean ports, and also by shipping the disassembled parts over land to be assembled there. In June, 1918, there were approximately 68 Austrian and German submarines based in the Adriatic, practically all of these operating from Cattaro; and 21 submarines, including 14 ex-Russian boats operating from the Dardanelles. Cattaro was an ideal base for submarine operations, being strongly fortified and practically impregnable in so far as attack by naval forces was concerned. Supplies to this place were sent either over land on a narrow-gauge railroad from Pola or else sent by water. The enemy surface craft were decidedly in the minority and it would have been entirely feasible to prevent supplies from reaching Cattaro by sea. To cut the rail communications would have required a military operation of considerable magnitude, in view of the strength of the enemy forces in this section. Even then the result would have been doubtful, for assuming that we could have forced the enemy to evacuate Cattaro by cutting off his supplies, they had already prepared eight other bases in the Adriatic from which their submarines could operate. The problem of destroying the bases in the Dardanelles was also impracticable. The Gallipoli

MEMBERS OF THE ALLIED CONFERENCE ON MINELAYING IN THE MEDITERRANEAN, HELD AT MALTA, AUGUST 6 TO 9, 1918.

(Page 131.)

PHOTOSTATIC CHART, SHOWING THE PROPOSED MINING OPERATIONS IN THE MEDITERRANEAN SEA.

(Page 128.)



PHOTOSTATIC CHART, SHOWING THE PROPOSED MINELAYING OPERATIONS IN THE ADRIATIC SEA.

(Page 132.)

(Page 135.) PHOTOSTATIC CHART, SHOWING THE PROPOSED MINELAYING IN THE ÆGEAN SEA.

campaign had been a failure. The British had laid mine fields about the entrance of the Dardanelles, but sweeping operations could be easily conducted by the enemy, whose shore batteries could keep off the allied men-of-war while operations were in progress.

The Commander United States Naval Forces Operating in European Waters had been endeavoring for some months to induce the other Allies to join with the United States in offensive operations against enemy submarines in the Mediterranean. A plan was proposed and partially developed by the Force Commander's planning section in January, 1918, which was subsequently accepted by the Allied Naval Council. This proposal was to lay a mine barrage in the Adriatic from the Italian coast to one of the Dalmatian Islands. After having been accepted by the allied council it was taken up for consideration with the military representatives of the Supreme War Council at Versailles, who finally concluded that the military situation on the western front was such that the necessary troops could not be spared to be sent to the Adriatic for seizing such of the Dalmatian Islands as would be necessary before the mining operations could be undertaken. Any other location in the Adriatic for a mine barrage involved depths of water of from 500 to 600 fathoms. The possiblities of constructing a mine suitable to these greater depths was, however, presented to the Bureau of Ordnance for solution.

On account of the North Sea barrage operations the United States Mine Force would be engaged well up into the fall of 1918, using up the mines practically as fast as they were manufactured, and none of the Allies were in a position to undertake mining operations in the Mediterranean on the scale required. The question of mining in these waters was therefore allowed to rest until June, 1918, when the Force Commander presented to the Allies an estimate of the general situation in the Mediterranean, including a discussion on the various locations in which mine barrages could be constructed.

In the meantime offensive operations had been undertaken in the Adriatic against submarines operating from Cattaro and Darazzo. A mobile barrage consisting of allied destroyers, submarines, trawlers, sloops, and United States submarine chasers had been established in the lower part of the Adriatic between latitude 39° 10′ north and 41° north. These vessels were equipped with hydrophones and depth charges and as many vessels as could be procured were provided in order to maintain a constant patrol over a considerable area. The vessels were, however, small, and even during the summer months it was frequently necessary for them to seek shelter during bad weather. The mobile barrage was not an effective antisubmarine measure.

The Italians and French had also undertaken antisubmarine measures in the Adriatic in the form of a mine net between a point 10 miles

offshore from Otranto across to Fano Island—a distance of about 35 miles. The 10-mile gap left at the Italian coast had been mined by four rows of mines. This net extended from 33 feet below the surface to 200 feet below. Experiments conducted during the previous winter had shown that the type of net adopted possessed greater endurance qualities than had even been hoped for. The two nations engaged in the project, however, were badly handicapped by lack of material for constructing the net and suitable vessels for placing it in position. On July 15, 1918, only 10 miles of the 35 had been completed. The necessary material to finish it had been promised by Great Britain and it was confidently expected that the net would be in place before the end of the calendar year. Patrol vessels were required to guard the surface above the net in order to force submarines to dive to the necessary depth to encounter it. It was also too shallow to be thoroughly effective. Recent information had shown that submarines did not hesitate to dive 300 feet and frequently even deeper if necessary. As soon as the enemy could discover the geographical position of this barrier it would be a simple matter for them to submerge sufficiently to pass safely beneath it. On July 30 an enemy submarine ran into the last section of the net which had been completed and was sunk almost immediately. This event, occurring just a few days prior to the date set for the Malta conference, aroused the enthusiasm of the French and Italians tremendously and made them decidedly partial to this form of antisubmarine measure in preference to a strict mine barrage.

Although the United States memorandum of the 17th of June revived the interest of the Allies in the possibilities of minelaying in the Mediterranean, it did not result in any active efforts on their part to further the project, so a second memorandum was prepared by the Force Commander on July 11. This was essentially a résumé of the former one and was sufficient to start active discussion. Comments were exchanged with the British Admiralty and a special emergency meeting of the Allied Naval Council was called in London on July 23 to discuss the possible projects. For this meeting there was prepared by the United States planning section an informal memorandum laying down certain fundamental principles which should be adhered to as far as practicable in the selection of locations and construction of mine barrages. This memorandum was incorporated in full in the report of the council. Although many of the points seemed too obvious, they were subsequently found to be invaluable at the allied conference held at Malta three weeks later, where many of the various impracticable proposals for possible mining operations made by different nations were easily disposed of by referring to the fundamental principles which had been adopted and approved by the allied council. By this means it was possible to reach agreements for mine

laying which would otherwise have been practically impossible on account of the controversies and arguments which would have been presented by the various nations.

These principles were:

(*a*) Both ends of a mine barrage should rest in own territorial waters to avoid the necessity for special military operations.

NOTE.—When military sources are available (*a*) may be modified to read (both ends of a mine barrage should rest in waters under military control from the shore).

(*b*) Both ends of a mine barrage should be secure against raiding operations, so that any possible military advance of the enemy will still leave the barrage effectively intact. If the enemy holds shore ends, he can sweep a channel safe for submarines under cover of shore patrols.

(*c*) Barrages should exclude submarines from operating areas. Barrages should be as short as possible on account of scarcity of available mine material.

(*d*) No enemy submarines should be able to gain the sea, except via the hazard of a mine barrage.

(*e*) A mine barrage extending to the surface is much more effective than any patrol can be, since it watches day and night, in good weather and bad, with equal efficiency.

(*f*) No deep barrage is effective unless it is thickly patrolled.

(*g*) Whenever a barrage to the surface is laid, the surface part of the barrage should be densest, because submarines prefer to navigate on the surface, and will dive only when their mission requires them to do so.

(*h*) When a surface antisubmarine barrage is laid, it should invariably be superposed on a deep barrage, to prevent submarines from diving under the surface barrage.

(*i*) There should be a secure harbor in advance of a barrage, so that any enemy naval raiding force reaching the barrage may be cut off by the force based on such harbor.

It was further recommended at this emergency meeting that the first efforts in constructing mine barrages in the Mediterranean should be: First, across the Straits of Otranto, and second, in the Aegean Sea. Both of these barrages, however, were dependent upon the possibility of surmounting the physical difficulties of mining in very deep water.

It was then arranged to hold an allied conference at Malta during the first part of August in order to discuss and make definite recommendations for mine-laying operations in the Mediterranean. Malta was selected on account of the convenience to the various allied commanders-in-chief in those waters, who were primarily concerned with the policies which were to be adopted. Rear Admiral Joseph

Strauss, Capt. Charles R. Train, and Lieut. Noel Davis were sent as representatives of the United States Government.

The conference met on the 6th of August, finishing its work on the 9th. The main items which were brought up for consideration and recommendation were:

(*a*) Dardanelles mine field—possibilities of extending and reenforcing it.

(*b*) Adriatic barrage.

(*c*) Cape Bon, Sicily, barrage.

(*d*) Aegean barrage.

(*e*) Gibraltar barrage.

(A) DARDANELLES MINE FIELD.

Mining operations off the Dardanelles had been previously carried out by the British. The field consisted of mines dangerous to vessels on the surface and was designed to bottle up the enemy men-of-war based at Constantinople and in the Black Sea. It was not effective against submarines as they could quite readily pass below the mines. Since the ends of the field rested on enemy shores, sweeping operations could be carried out under the protection of the shore batteries. On the other hand, the mines were laid mostly at night, in small groups, variously placed, and served more as a trap than as a barrage. The undertaking was of small magnitude and, since the effects had already been rewarded with some success, and the mines were available, it was recommended that the work should be resumed. There was also the possibility that after the collapse of Russia their Black Sea Fleet had been put into commission by the enemy. This would have given them a comparatively strong force of surface vessels to engage the Allied Aegean Fleet or to be used as raiders on the Mediterranean commerce. The Dardanelles mine field might possibly be sufficient to prevent them from leaving their bases. In view of the availability of material and the noninterference with other operations, this work was given priority over other minelaying projects in these waters.

(B) ADRIATIC BARRAGE.

The Adriatic mine barrage offered greater possibilities as an antisubmarine offensive than any of the other projects proposed for the Mediterranean. A successful mine barrage from coast to coast across the Straits of Otranto would have bottled up practically all of the submarines which were operating in the Mediterranean.

Unfortunately, the selections which were strategically the best involved water of depths too great to be mined with any types of mines which were then existent. The Bureau of Ordnance had been investigating the possibility of producing such a mine, and on the

day the conference met a cable dispatch to Admiral Strauss announced that the bureau was prepared to construct mines for mining in depths up to 500 fathoms. In discussing the various possible locations for the Adriatic barrage, some trouble was encountered with the French and Italian representatives, who were opposed to the most desirable selection on the grounds that it might interfere with their fleet movements. A barrage between Cape Otranto and Cape Linguetta was preferred by the United States, British, and Japanese representatives, for, besides being shorter, there were no depths exceeding 500 fathoms, for which the Bureau of Ordnance had stated they could prepare the necessary material. The French and Italian representatives, however, desired to place the barrage farther to the southward, extending from Fano Island across to some point on the Italian coast, between Cape Otranto and Cape Santa Maria Di Leuca. This position, however, was beyond consideration by us at that time, since it involved depths of water as great as 600 fathoms. In spite of the fact that the United States was offering to provide all the material and do all the work in connection with the construction of the barrage, it was impossible to reach an agreement with the Italian representative which could be accepted by the United States on account of the mechanical difficulties involved. In the final recommendations of the conference it was stated:

> If, however, the objections presented by Italy could be overcome, the conference was of the opinion that a complete mine barrier, with suitable gate, between Otranto and Cape Linguetta should be laid in preference to the one proposed between Cape Santa Maria Di Leuca and Fano Island. This would be done with the material already designed, as the water was shoaler and moreover the barrier would be less exposed to the sea.

Admiral Salazar (Italian Navy) did not concur with the mine barrier being placed in this latter position.

The details of the barrier were left almost entirely to the United States representative, who proposed that the barrage should extend from 10 feet below the surface to 285 feet below the surface. This represented an increased depth compared with the North Sea barrage, which was desirable on account of the fact that submarines were capable of diving to greater depths than had formerly been possible. In order to care for the shipping to the ports in the Adriatic it was necessary to leave a small gate at some point in the barrage. This was decided to be left in the western end and was not to exceed 5 miles in width, and should be narrowed in the future should experience warrant its reduction. This gate was to be free of all mines down to a depth of 40 feet and was to be thoroughly patrolled by craft capable of fighting submarines and in sufficient number to compel submarines to dive into the minefield below the gate.

In order to avoid any mixed responsibilities for the execution of the project, the United States accepted the task of providing and laying the mines, and insisted that the operation of laying, controlling, and maintaining the barrage be entirely under the jurisdiction of the United States. This was approved by the conference.

It appeared that Admiral Revel, the Italian chief of naval staff, was supreme in deciding the policies and attitudes of naval operations which involved the Italian Government. Intimation was given the United States representative that by referring the question of the location of the barrage to him it might be possible to obtain the Italian Government's approval of the location desired by the United States. This was immediately taken in hand, but his reply was not received prior to the completion of the conference. One valid objection to the barrage being placed on the line from Otranto to Cape Linguetta lay in the fact that the military situation in Macedonia was at that time somewhat critical. There was a possibility that the enemy might concentrate his forces in an attempt to capture Valona Bay. With this in enemy possession, the eastern end of the mine barrage would have been extremely difficult to maintain.

(c) CAPE BON-SICILY BARRAGE.

A mine field extending from Cape Bon, Tunis, to the Island of Sicily presented several features above those offered in the Adriatic and Ægean Seas. In the first place, the water was sufficiently shallow to enable the present type of United States mines to be used, of which there would be sufficient available by the time the work could be undertaken by the mine force. A barrage in this position would serve to restrict the operations of submarines which were based at all of the enemy ports in the Mediterranean, to the eastern part of the Mediterranean. Since approximately 70 per cent of the Mediterranean shipping took place to the westward of the Cape Bon-Sicily line, a barrage in this position would have been comparatively effective from a protective point of view. For these reasons the United States considered this should be the primary project in order to relieve the losses of shipping at as early a date as possible. The British, French, and Italian representatives did not approve of a mine field in this position, unless very large gateways could be left which would render the barrage practically useless, and further wished a guarantee that vessels could safely pass over the deep mine fields which were to be laid beneath the gates. In addition, submarine operations would then be concentrated on the shipping in the eastern Mediterranean, which was engaged principally in transporting troops and carrying supplies to the allied forces in Saloniki, Mesopotamia, and in Egypt. It was evident that it would be impos-

sible to obtain the assent and co-öperation of our allies to construct a satisfactory barrage in this position, and the idea, therefore, had to be abandoned.

(D) ÆGEAN BARRAGE.

It was comparatively easy to obtain the approval of the various allied representatives for the location of a barrage in the Ægean Sea in the position desired by the United States Government. These waters, crowded with islands, presented many locations in which a barrage might be constructed. In order to reduce the number of mines required, it was desirable to utilize the islands by blocking the passes between them. One end of the barrage must necessarily rest on enemy shores and the site which presented the greatest possibilities of maintaining a mine field was at Cape Kanapitza. The project included a plan for establishing a garrison on the Island of Samos for the purpose of guarding the narrow channel between that island and the Turkish mainland. As this channel was narrow, it could easily be guarded by artillery on shore, so as to prevent sweeping operations by the enemy, once the mine field had been laid. The location decided upon, and approved by the conference, began at Eubœa Island, and ran to Andros, Tinos, Mykoni, Nikaria, Themina, Furni, and Samos Islands, and thence across to Cape Kanapitza. This barrage was similarly to consist of mines from 10 feet to 285 feet below the surface, with a gate between 500 and 1,000 yards wide, free of surface mines, to be placed either in Doro Channel or in Steno Pass. The recommendations of the conference also provided, as they had done for the Adriatic barrage, that the responsibility for the provision, laying, and maintenance of the mine field should be left entirely to the United States.

(E) GIBRALTAR BARRAGE.

Aside from the deep water and the very strong currents in the Straits of Gibraltar, the advantages to be gained by a barrage in this position were not of sufficient importance to demand the development of the special mine which would have been required for this purpose.

In addition to the mine barrages in the Adriatic and Ægean, the United States became involved in two minor projects which, while considered of secondary importance by our representatives, were agreed to on account of the great desire of the British and Italians to have these measures carried out. The first was to supplement the mine net which was being placed between Otranto and Fano Island. This net extended only to a depth of 200 feet and in order to make it more effective the United States agreed to place four rows of mines below it and in the immediate vicinity so as to

complete the barrage to an approximate depth of 300 feet. The second project was to assist the British in the Dardanelles mine field by laying surface mines between Imbros Island and Cape Gremea. This was acceded to by Rear Admiral Strauss, since it would require comparatively few mines suitable for the deeper water involved. Great Britain at that time had no such deep mine in sight. The work was not to be undertaken until after all other projects in the Mediterranean had been completed.

Further minor operations were discussed by the conference in connection with the protection of the trade routes through the Gulf of Patras and the Corinthian Canal around to Saloniki, and also the protection of Eubœa Channel in order to form a safe drill ground for the Ægean allied men-of-war. These were minor operations and did not involve the United States.

Upon the completion of the conference, Admiral Strauss, accompanied by Commander Train and Lieut. Davis, left Malta to inspect the various sites suitable for the construction of a mine base in the Mediterranean. Argostoli, Corfu, and Taranto were inspected prior to returning to Base 18. Corfu appeared to present the greatest possibilities, although there were absolutely no facilities available on shore which could be used in connection with mining, or in the erection of an assembly plant. It also possessed the disadvantage of being within bombing distance of the enemy.

While in Rome an unofficial report was received from the Italian Chief of Naval Staff that the position preferred by the United States and Great Britain for the location of the Adriatic barrage would be acceptable to the Italian Government, except that they preferred the western end of the mine field to terminate at Cape Cavallo instead of Cape Otranto. This news was most welcome. The new position and the alterations suggested by the Italians were equally acceptable, since it involved slightly shallower water than the Otranto line, but was somewhat longer. This unofficial report was later confirmed officially.

On September 13 and 14 the fifth meeting of the Allied Naval Council was held in Paris to consider the recommendations of the Malta conference and to decide upon the policies which should be inaugurated. The recommendations were approved by the council almost verbatim. The following priority for the establishment of the barrages was laid down:

(1) Completion of Dardanelles mine fields, in accordance with existing plans.

(2) Adriatic.

(3) Ægean.

(4) Entrance to Eubœa Channel.

(5) Entrance to Gulf of Patras after completion of the Aegean barrages.

(6) Embros to Cape Gremea to be laid if and when material was available.

In regard to reinforcing the Italian-French mine net barrage by four lines of deep mines, it was decided that not only should mines be laid below the net as previously agreed at Malta, but also above the net so as to eliminate the necessity for a patrol, which there, as in the North Sea, had been found to be almost entirely ineffective in preventing the passage of submarines. Where the depth of the water was too great to permit mines to be laid to reinforce the net, the net should, if possible, be increased so as to reach to a distance of 285 feet below the surface of the sea. In order to establish a complete barrage across the Adriatic at the earliest possible moment, it was later decided by the United States Government that the work of supplementing this net should take priority over the main Adriatic barrage.

Several days before the meeting of the Allied Naval Council a resolution had been conveyed to the Supreme War Council at Versailles in regard to the necessity of taking all possible measures in Albania, to prevent Valona from falling into enemy hands. This resulted in Italy informing the Allied Naval Council that the measures for reinforcement which had already been taken were then proving effective.

It was decided that the selection of a base for mining in the Mediterranean should be left to the discretion of the United States who was responsible for the provision and execution of the major mining operations in the Mediterranean. They further requested that the Government in whose territory the base was chosen should give all possible support and assistance for the early construction of the mining depot.

In the meantime detailed plans for the Adriatic and Aegean barrages were developed by Commander Mine Force, and the necessary mines were requested to be prepared by the Bureau of Ordnance. Both barrages were to consist of mines at four depths so as to form an effective field from the surface to a depth of approximately 300 feet. The surface mines were to be fitted with 30-foot antennæ and were to be laid in 10 rows, spaced 300 feet apart in each row. There were to be four lines of mines at each of the three lower levels, the mines also spaced 300 feet apart in each row, and these were to be fitted with 70-foot antennæ. This would have given the barrage a theoretical destructive efficiency of 65.6 per cent for submarines passing through the barrage within 50 feet of the surface, and 34.4 per cent against those passing between 50 and 300 feet below the surface. (Assuming beams of submarines to average 30 feet.) This required the use of 22,800 mines for the construction of the primary mine barrage in the Adriatic with 8,000 additional mines for supplementing

the Franco-Italian mine net with four rows of mines above the net and four below where the depth of water would permit. For the Aegean barrage there would be required 26,800 mines. This made a grand total for the Mediterranean of 57,600 mines or approximately 75 per cent of the number that it was intended to place in the North Sea barrage.

The selection of a base for assembling mines in the Mediterranean presented considerable difficulties. The few suitable harbors in Italy were so overtaxed by their naval requirements as to render them out of the question. Corfu, located within convenient distance of the contemplated barrages in the Adriatic and Aegean, appeared to be the most suitable position. Its greatest drawback was, however, the possibility of enemy air raids, which, had they been successful, might have completely destroyed the base by blowing up the mines in storage there. The most suitable location so far as natural facilities were concerned was Bizerta, Tunis, and even here the facilities were almost nothing. Its principal disadvantage was the great distances from the contemplated barrages—560 miles to the Adriatic and 775 miles to the Aegean—and through waters infested with enemy submarines. These distances were a most serious handicap, even so much so that it would have prevented two of the vessels of the mine force from taking part in the construction of the Aegean barrage on account of their limited steaming radius. In spite, however, of the disadvantages entailed it appeared to be the most suitable location that could be obtained and on September 28, Capt. O. G. Murfin, United States Navy, who had established and commanded the mine bases in Scotland, left London to establish a base at that place.

With practically unlimited resources to draw upon, it had required four months to construct the mining bases in Scotland. To duplicate such an assembly plant in Bizerta would undoubtedly have required at least the same length of time and possibly much longer. It was, therefore, apparent that the first operations in the Mediterranean must be carried out with mines assembled at Bases 17 and 18, and arrangements were made to have the necessary mining material shipped to those bases for two operations. This would allow approximately two months' additional time for the completion of the base at Bizerta before they would be called upon to supply the vessels with assembled mines.

Arrangements were made to obtain the necessary material for the erection of assembly sheds, living quarters, storage plants, etc., from the U. S. aviation forces in France with some additional mine-shop equipment from Bases 17 and 18. It was necessary also to construct a pier at Bizerta for unloading the mine carriers and for supplying the minelayers with assembled mines. Capt. Murfin arranged con-

tracts through the local French naval authorities and the work of construction on the pier was immediately undertaken.

The U. S. S. *Lakeside*, after discharging her cargo of mine parts for Base 18, was loaded with such assembly material and other equipment as could be spared from that base, and then was dispatched to Pauillac, France, where the aviation material was to be taken on board. The U. S. S. *Lake Shore* was similarly dispatched two days later, proceeding to Bristol to be loaded with construction material.

The French did all in their power to advance the work of construction, and after less than one month's hard work the ground work of the base was well in hand.

The armistice with Turkey on October 31 and the occupation by the Allies of the Dardanelles and the Bosphorus eliminated the necessity of a mine barrage in the Aegean. Following close on top of that came the armistice with Austria-Hungary on November 4. Although many of the submarines based at Austrian ports were German and might possibly escape and operate in the Mediterranean, these operations could only be of short duration and would undoubtedly cease before our mining operations could be undertaken. On November 7 orders were, therefore, issued to discontinue work in connection with the establishment of the mine base at Bizerta. At the same time the Bureau of Ordnance was requested to suspend the production of mines for the Mediterranean projects. The end of the war had fortunately come before it had been possible for us to lay a single mine in those waters.

The work of demobilization of the Bizerta base began almost immediately. The *Lake Shore* and *Lakeside*, neither of which had reached their destination, were returned to Inverness and unloaded. Most satisfactory arrangements were concluded by Capt. Murfin for the disposition of the material which had been supplied for the construction of the necessary buildings at the base. The French authorities took over practically everything that could be used and much of the remaining scrap material was disposed of to local merchants, leaving the United States indebted only for the cost of actual labor which had been expended and such construction and material as could not be further utilized.

The Allied Naval Conference, in its session at Malta on August 6 to 9, 1918, touched on the question of the removal of the mines at the end of the war. This subject was taken up more thoroughly at the meeting of the Council held in Paris on September 13 and 14, and still more thoroughly at the meeting of the Council held on October 31, November 1, 4, and 5 in London.

As a result of conferences held in London by the Allied Naval Council on October 31 and November 1, 4, and 5, 1918, concerning clearing the seas of mines after the war, it was recommended that

Great Britain undertake to collate from the allied, associate, and central powers and distribute to the maritime countries of the world, intelligence regarding progress of mine clearance operations.

A committee of British naval officers with offices at the Admiralty in London, known as the International Mine Clearance Committee, has been convened to collate this information and in accordance with a further recommendation of the Allied Naval Council mine clearance intelligence officers were appointed by the allied and associated powers to co-öperate with this committee.

Mine warnings to mariners were issued from time to time by the International Mine Clearance Committee and information received from all reliable sources as to progress in minesweeping were communicated to the mine clearance intelligence officers for transmission to their various governments.

In a memorandum from the British Admiralty to the Commander-in-Chief dated December 7, 1918, it is stated as follows:

950. Arrangements are being made by which warnings of mine fields and indispensable routes will be promulgated internationally from London:

2. This will be done by British authorities by issue of Admiralty mine warnings to mariners—similar to Notices to Mariners, and printed green to distinguish, and by telegrams to reporting officers prefixed "Route warnings."

3. This system will be introduced gradually and will replace existing system of orders regarding routes which will be canceled as necessary.

4. Route warnings and mine warnings to mariners will be classified by areas as in paragraph 8. Route warnings will be numbered serially in each class and will commence with title of area, thus: Route warning North Atlantic 3—Mine warnings to mariners will be numbered consecutively irrespective of areas.

5. When orders for any area become sufficiently simple they will be communicated to all reporting officers. Orders for other areas will at first be confined to route giving officers to whom vessels concerned must then be ordered to apply.

6. Route warnings will give the most up-to-date information and should be used to amend mine warnings to mariners when routing vessels.

7. Other governments will be given similar information through their representatives in London.

8. Areas of classification of route warnings. Limits will be given in subsequent route warnings. General, comprising notices affecting all areas.

1. Arctic.
2. North Atlantic and English Channel
3. West coast of United Kingdom.
4. North Sea.
5. Baltic.
6. East coast of France, Spain, and Portugal.
7. Mediterranean.
8. South Atlantic, Indian Ocean, Red Sea, and Pacific.

In accordance with the above-outlined policy, the International Mine Clearance Committee has issued 245 mine warnings to mariners. The first of these, No. 1 of the year 1918, was issued on the 10th of December of that year. This was a general outline plan of the operations of that office. Mine warning to mariners No. 2 issued on the same date gives geographical areas to which all mine warnings, subject to issue, are referred; in all, eight zones. Mine warnings to

mariners No. 3, 4, 5, 6, 7, 8, 9, 10, all issued also on the 10th of December, describe the conditions of all the areas on that date and are published herewith in explanation of the policy that was to be carried out. In connection with these mine warnings to mariners, there were published a series of charts showing the mine areas and safe channels. These were republished by the United States Hydrographic Office for the information of all mariners, in some cases being published as a supplement to the United States Pilot Chart.

Nothing could more graphically show than these charts the extent of surface that was dangerous to shipping by reason of mined areas. The degree of danger is shown on the chart by the various forms of shading. In the general chart British Islands, Dunbar to South Forland, showing the east coast of England, it is made very clear what a very restricted area was considered safe for navigation, even when assisted by the exhaustive system of buoys as shown on that chart.

The removal of the mines began almost as soon as the armistice was signed. From the professional point of view, this operation was much more arduous and difficult than planting the mines. Mine warnings to mariners and charts showing the areas cleared were published from time to time in order that maritime commerce should be kept apprised of the areas still remaining dangerous. The description of this enormous operation of mine clearing will form the matter of a subsequent publication.

INDEX.

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