# Navy Ordnance Activities

## World War
## 1917-1918

WASHINGTON
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1920

U. S. S. FLORIDA FIRING A BROADSIDE.

II-1

NAVY DEPARTMENT,
*Washington, January 25, 1920.*

MY DEAR ADMIRAL: The Bureau of Ordnance, under your direction, played a very important part in the Navy's successful work during the World War, and therefore it is desirable that this work of the bureau should be recorded at greater length and in more detail than can be done in your annual report.

Such a narration of the work of the bureau will be of value to the Navy and of great interest to all those engaged in the production of ordnance material, civilian as well as naval, and will serve as a record to which reference can be made with advantage should the country unfortunately ever be faced with a similar emergency.

Very sincerely yours,
JOSEPHUS DANIELS,
*Secretary of the Navy.*

Rear Admiral RALPH EARLE, U. S. Navy,
*Chief of Bureau of Ordnance,*
*Navy Department, Washington, D. C.*

NAVY DEPARTMENT, BUREAU OF ORDNANCE,
*Washington, D. C., May 1, 1920.*

MY DEAR MR. SECRETARY: In accordance with the directions contained in your note of October 1, the bureau has prepared this record of its activities and trusts that all who are interested in the Navy will find pleasure in reading this authoritative statement of the ordnance portion of the Navy's work in the World War.

The preparation of this record was accomplished with the assistance of the present chiefs of the divisions and sections of the bureau as follows:

| | |
|---|---|
| Assistants to the bureau | Captains T. A. Kearney and C. C. Bloch, U. S. Navy. |
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| Cost board and contracts | Commander John H. Moore. |
| Buildings and grounds | Lieut. Commander W. W. Little, R. F. |
| Patents | Mr. P. A. Blair. |
| Requisitions | Mr. F. B. Blackburn. |
| Special board on naval ordnance | Rear Admiral N. E. Mason; and |
| Contracts and merchant ship protection | Rear Admiral A. R. Couden. |

the main editing and compilation being the handiwork of the Chief of Bureau; Lieut. Commander T. C. Kinkaid, U. S. Navy; Lieut. Commander T. S. Wilkinson, jr., U. S. Navy; and Chief Gunner R. E. Cox, U. S. Navy.

Very respectfully,

RALPH EARLE,
*Chief of Bureau.*

The honorable JOSEPHUS DANIELS,
*Secretary of the Navy.*

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# INTRODUCTION.

The preparation of this record of the Navy's ordnance during the war had its inception in the desire fittingly to recognize, record, and set forth the services rendered the Navy and the bureau, not alone by line officers of the Navy, deprived of an opportunity to secure war service afloat, because work of the shore establishments had to continue and at a higher rate of pressure than ever before, but also by the reserve officers, the technicists enrolled in class 4; to the end that all these might retain in after years this plain story of duty well done, and that they might feel, in a measure, the bureau's appreciation of the assistance they so splendidly rendered Navy ordnance during the days of hostilities.

The following pages also relate in some degree what has been accomplished, and how the duties of this bureau, charged by law with the design, acquisition, production, and issue of the fighting weapons of the Navy, were performed during the war with the Imperial Governments of Germany and Austria, from April 6, 1917, to November 11, 1918, a period of 19 months.

The officers of this bureau, to whose lot it fell to perform work ashore in this country, strove hard to be worthy of the trust and responsibility placed upon them by their fellow officers, who were under the heavy strain at sea of destroyer, convoy, patrol, mine-laying, mine-sweeping, submarine, aviation, and battleship duty; by day and night, in fair and foul weather, exposed to the dangers of the sea and the enemy's attack, throughout warfare of a type previously unknown and undreamed of in civilized times. We hope that these men believe our work was well done; we must be satisfied, even though we should have felt favored indeed had it been our lot similarly to share the hardships and hazards of duty at sea.

The bureau feels that, to all those who read intensively the history of the World War, there must come the conviction that, after all, naval power was the *ultima ratio* of this titanic war. So let us all, officers, naval and civilian personnel of this great Navy, continue to work for the constant improvement and betterment of the naval profession upon, beneath, and above the seas.

RALPH EARLE,
*Chief of Bureau of Ordnance.*

MAY 1, 1920.

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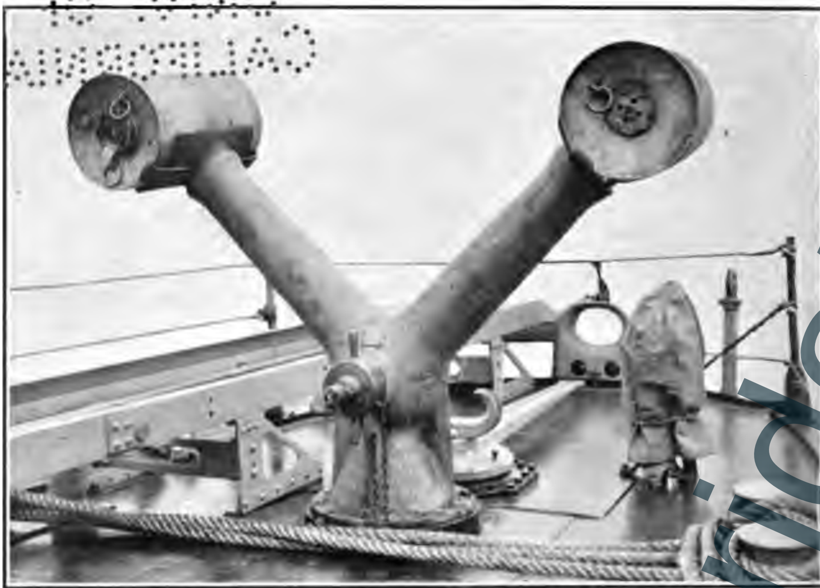
JAMES C. WILSON, of Texas.

Mr. Kettner. Mr. Venable.

stopinal. Mr. Farr. Mr. Wilson.



"Y" GUN WITH DEPTH CHARGES IN POSITION READY FOR FIRING.

PROJECTILE FOR "Y" GUN, SHOWING DEPTH CHARGE ATTACHED TO ARBOR.

In the upper right corner may be seen the base of the "Y" gun casting.

## THE "Y" GUN.

To damage seriously a submarine under the surface required that the depth charge explode within approximately 100 feet of her hull, and this, in turn, required fairly accurate knowledge of the location of the submarine, making due allowance for the advance beyond her track on the surface and for the time necessary for the sinking of the charge to the depth for which the index was set. One depth charge properly placed is sufficient to destroy a submarine, but, due to difficulties in locating the submarine, the usual practice was to drop a series of charges at intervals of 10 or 15 seconds, depending upon the speed of the destroyer. This insured damaging the submarine, provided her tracks were sufficiently distinct to enable the destroyer to follow down her wake, and, also, provided that the submarine did not change course. In most cases, however, the submarine changed course as soon as her presence was discovered, and there was no means of knowing her new course and speed, or her location at any moment.

To overcome this difficulty, the British invented and put into service the Thornycroft depth charge thrower, consisting of a single barrel within which fitted an arbor, or stem, to the outer end of which was secured, by adjustable clips or by lashings, the standard British depth charge. This equipment made it possible to throw depth charges out from the side of the ship, in addition to dropping them off the stern, and a sort of barrage was formed, which very much increased the probability of bringing the submarine within the danger zone of a depth charge. Due to the manufacturing difficulties, production of this weapon was slow and limited, and, if destroyers were to be equipped rapidly with depth charge throwers, another type was essential.

Shortly after this country entered the war, the bureau received from the Admiralty photographs and designs of the Thornycroft depth-charge thrower. The possibility of applying the principle of the Davis gun to a depth charge thrower was conceived by Lieut. Commander A. J. Stone, R. F., formerly of the General Ordnance Co., Groton, Conn. The question of the most desirable form of such an apparatus was taken up by him with Mr. L. Y. Spear and then was referred to Mr. G. C. Davison, both officials of this company and graduates of the United States Naval Academy. After making the calculations necessary for the working design, the company undertook the production and tests of the first gun, the order for which was placed with the New London Ship & Engine Co. by the General Ordnance Co.

This **Y** gun, so called because of its two barrels at an angle of 45° from the vertical, throws two standard 300-pound depth charges at a time in opposite directions, and destroyers equipped with them were able to produce a barrage of wide pattern, which greatly increased the efficiency of offensive tactics against submarines. By using different sizes of impulse charges, ranges of 50, 66, and 80 yards could be obtained and this feature made variations possible in the pattern of depth charges laid down. The simplicity of this gun made its rapid production possible and no time was lost in placing it into service, where it did splendid work.

The first contract for Y guns was let to the General Ordnance Co., Groton, Conn., on December 8, 1917, but work had been begun on November 24, in advance of the contract, and the first deliveries were made December 10, 1917. Of these guns, 947 were actually put in service. They were installed on destroyers and subchasers, where their use proved their worth quickly. This Y gun was one of the unique and most successful weapons produced in the offensive game against the submarine.

# CHAPTER VII.

# NORTH SEA BARRAGE, OR NORTHERN BARRAGE.

**(THE MARK VI MINE.)**

## I.—ADOPTION OF THE BARRAGE PROJECT.

The Bureau of Ordnance, even before the United States entered the war, had made a close study of the possible measures to be taken to counteract the submarine peril. It was obviously 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 plan was 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 Europe. It was the opinion of the bureau that such a 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.[1] The proposal to construct a barrage 230 miles long was so novel and unprecedented, that it was realized at the time that it would be difficult to obtain a prompt decision to establish it.

Considerable doubt of the success of such an undertaking was expressed in this country; and the British Admiralty, when it was first suggested, believed it almost impracticable. Mine barriers were not considered wholly effective, unless maintained by patrols at all points. Patrols could not be properly protected on such a long line as from Scotland to Norway, because the defense would be stretched out in a long and locally weak line, and, therefore, subject to enemy

[1] It will be easily recalled by those cognizant of the progress of the war that in the fall of 1917 the submarine warfare of the Germans was causing tremendous losses and threatening to prevent the active help of the United States on the Western Front. In fact, in May, 1919, Mr. McNamara stated to the House of Commons that during the war merchant shipping to a total of 12,750,000 tons had been sunk by actions of the enemy, and that out of this tonnage 7,500,000 tons were British.

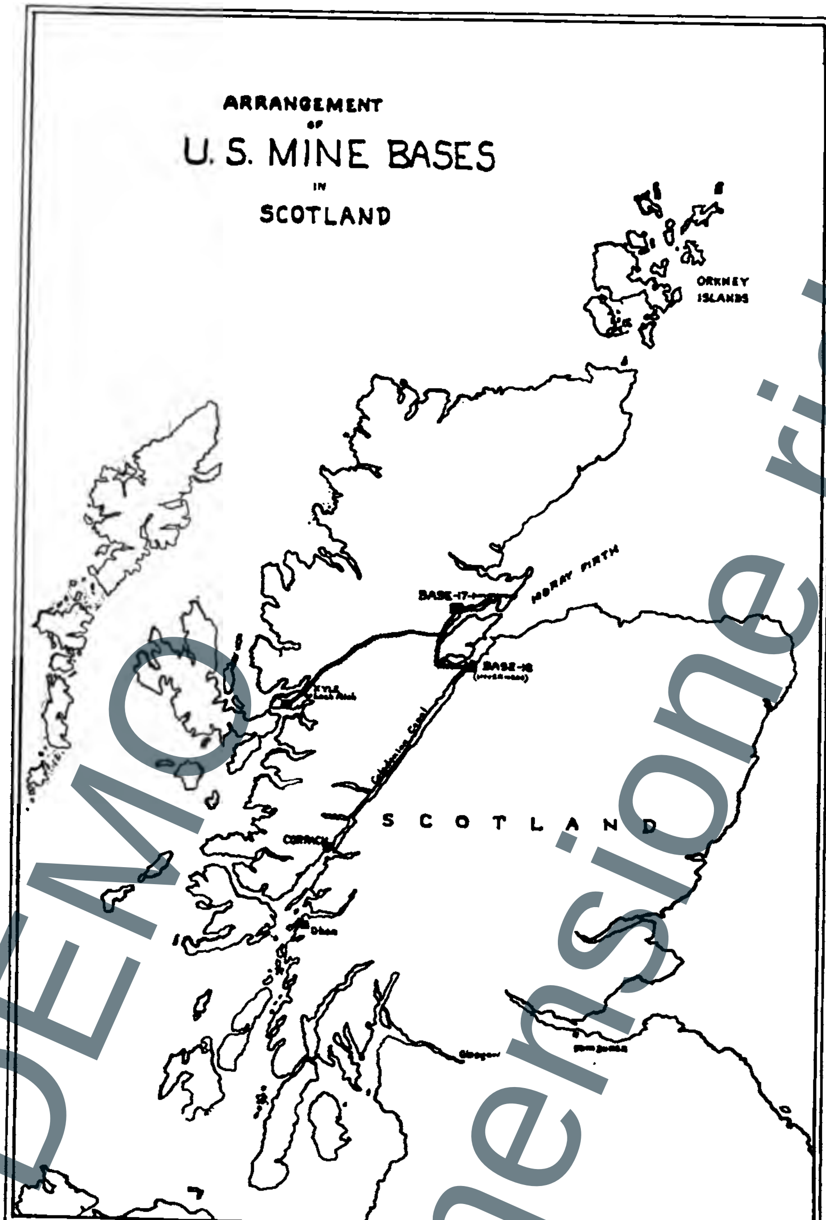
raids in sufficient force to break through the patrol and clear a passage for the submarines. If the patrols were protected with heavy vessels, these would be exposed to the German policy of attrition with torpedo attack. In short, bitter and extensive experience had forced the abandonment by the British of any serious attempt at blockading such passages.

Notwithstanding the unfavorable attitude toward the further consideration of the barrage project, its proponents—that is, the officers of the Bureau of Ordnance—redoubled their efforts to secure its adoption, feeling that the hastening of a favorable issue of the war depended upon it, surely as much as upon any other possible naval measure. While the entrances to the North Sea were very broad, and presented immense difficulties, it was believed that they came within the bounds of possibility of control.

From early in March until the latter part of July, 1917, an intensive study was made in the Bureau of Ordnance by Commander S. P. Fullinwider and his officer assistants of many types of barrage, among them the submarine trap and indicator nets which had been used by the British. The majority of the plans considered were devised within the bureau, but in addition a 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 millpond conditions, whereas the waters in which such a barrage as that under consideration 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 the depth of water in which the proposed barrage would have to be laid was quite prohibitive.

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 exceedingly 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


ARRANGEMENT
OF
U. S. MINE BASES
IN
SCOTLAND
ORKNEY
ISLANDS
MORAY FIRTH
BASE-17
BASE-18
Caledonian Canal
S C O T L A N D
Oban

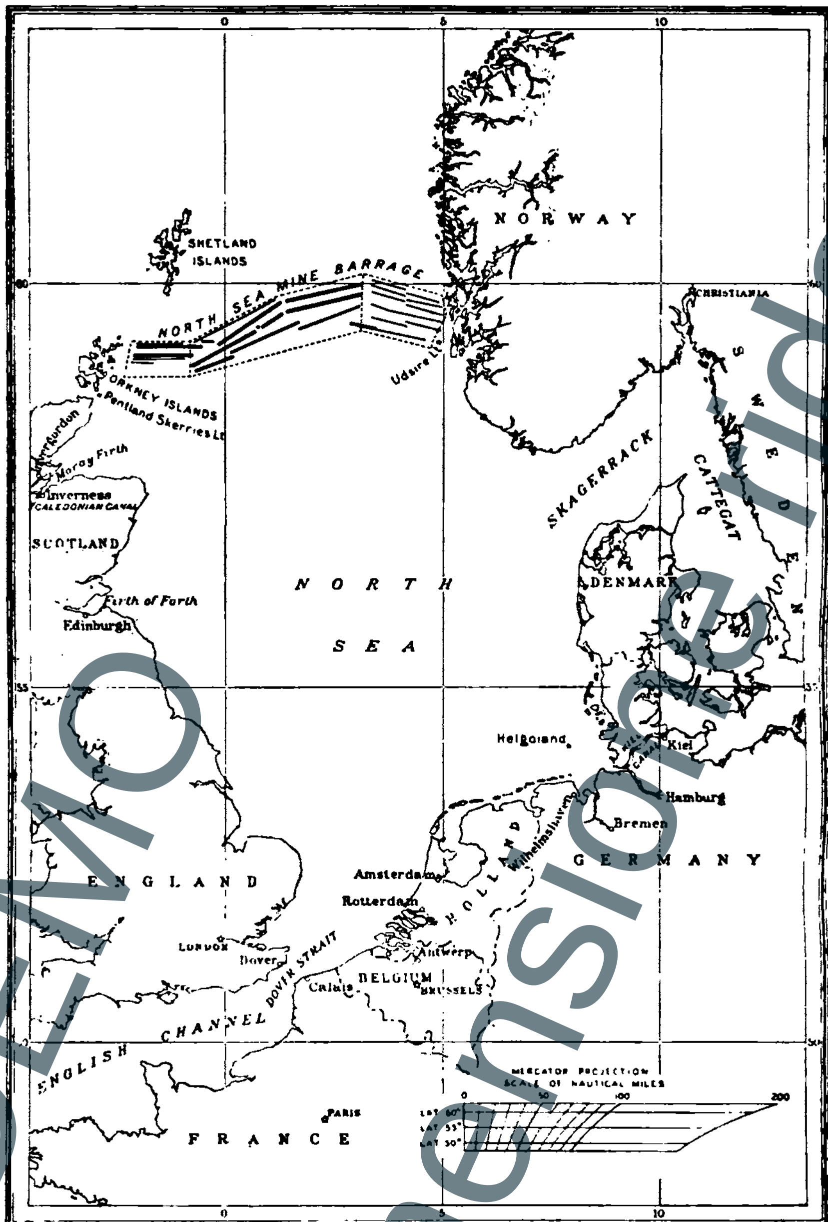



CHART OF THE NORTH SEA, SHOWING THE LOCATION OF THE MINE BARRAGE LAID BY THE AMERICAN AND BRITISH MINING SQUADRONS to design a mine especially adapted to the purpose. Such a mine must incorporate many new features, to embody which extensive study, design, and tests were essential. Some of these requirements were quick-loading mine cases; anchors adapted for use in far greater depths of water than any hitherto contemplated and of much greater reliability and ruggedness; an assembly of anchor and mine that permitted their planting as a unit, accurate and at high speeds; a firing device widening the danger zone of each mine; and so on. It was evident that in order to reduce the number of mines required for the barrage a mine should be developed which would explode not only when struck by a submarine, but also when a submarine passed close by.

In May, 1917, development was started on a mine-firing device fulfilling this condition. The successful production of this firing device was primarily the work of Commander S. P. Fullinwider, U. S. Navy (ret.), and Lieut. Commander T. S. Wilkinson, jr., U. S. Navy. The start on the device finally adopted was made immediately pursuant to the suggestion of Mr. Ralph C. Browne, a citizen of Salem, Mass., who submitted an electrical device to be used on what he termed a Browne submerged gun. The officers of the bureau concerned with this, that is, the Chief, Assistant Chief, and Chief of Mines and Net Section, believed the principle could well be adapted to a mine. The inventor of this principle was, therefore, placed in collaboration with the above mentioned officers of the bureau, and Commodore S. J. Brown (Math.), U. S. Navy, with the result that a useful and efficient firing device was produced and tested at New London in June, 1917. During these tests, made on submarines both under way and at anchor, the device functioned in every case. On July 10, further tests were conducted, which determined not only that the principle was sound, but also that there was a satisfactory factor of safety.

The possible disadvantages of this firing device had been taken into consideration. The device would necessarily have to be very sensitive. This sensitiveness might make it possible for the gear to be operated mechanically, as by handling, wave action, or the explosion of an adjacent mine. It might make the gear so delicate that it would become inoperative readily. There was not enough time available for a thorough investigation of the principle of the device, and, in places where the conditions differed from those along the New England coast, there might be something which would cause either spontaneous operation or render the device inoperative. Nothing was known, or could be ascertained in such a short time, as to the effect of continued submergence. Quantity production would inevitably give rise to troubles, which had not been encountered in the

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models. New constructions invariably develop faults in service, which can not be predicted.

While the models were being built, and the first tests were being conducted, officers of the bureau studied the situation and came to the conclusion that it was possible to overcome the troubles anticipated, and that while it was impossible without further experience to design a firing gear which would function *perfectly* in the field, it was feasible to produce, before the spring of 1918, one which, at the worst, would give results comparable with those being obtained by other nations and which would be sufficiently good to warrant its use in the barrage. This firing device was, therefore, finally adopted, shortly after the tests at New London.

While this new firing mechanism showed great promise from the first, it was felt to be unwise to place too great reliance on it before it had been thoroughly tested. Therefore, studies of other means of forming a barrage were continued without cessation, until the latter part of July. When the new mechanism had been brought to such a state of development as to warrant its adoption, the bureau decided to abandon all other plans for a barrage and concentrate on a mine embodying this mechanism, which came to be called the Mark VI mine, as it was the sixth type of mine developed by the bureau. The use of this mine reduced the number of mines required for a barrage across the North Sea by two-thirds.

The first tentative plans for a North Sea Barrage were submitted by the bureau to the Chief of Naval Operations, Admiral Benson, on June 12, 1917. The bureau, on July 18, 1917, announced the development of a mine—this Mark VI—peculiarly adaptable for use against submarines; and then, on July 30, 1917, furnished plans for a British-American joint offensive operation involving its use in a barrage across the North Sea. These plans received the approval of the Secretary of the Navy and Admiral Benson, and were then submitted by Admiral Mayo in person to the British Admiralty in late August, 1917.

In September, plans were prepared in the Admiralty for restricting submarines to the North Sea, which were generally in accordance with the original proposition of the Bureau of Ordnance—a barrage between Scotland and Norway, to be a joint British and American operation, and a short barrage across the Dover Straits, to be laid by the British. These plans were sent to the Navy Department and were taken up at a conference on October 15, attended by Admiral Benson, Admiral Mayo, the Chief of Bureau, Commander Fullinwider, and members of the staff of naval operations.

The adoption of the project seemed so certain at this time, that the Chief of the Bureau of Ordnance was, at his request, authorized to

GERMAN MINE OF TYPE PLANTED BY SUBMARINE. RECOVERED BY BRITISH NAVY.

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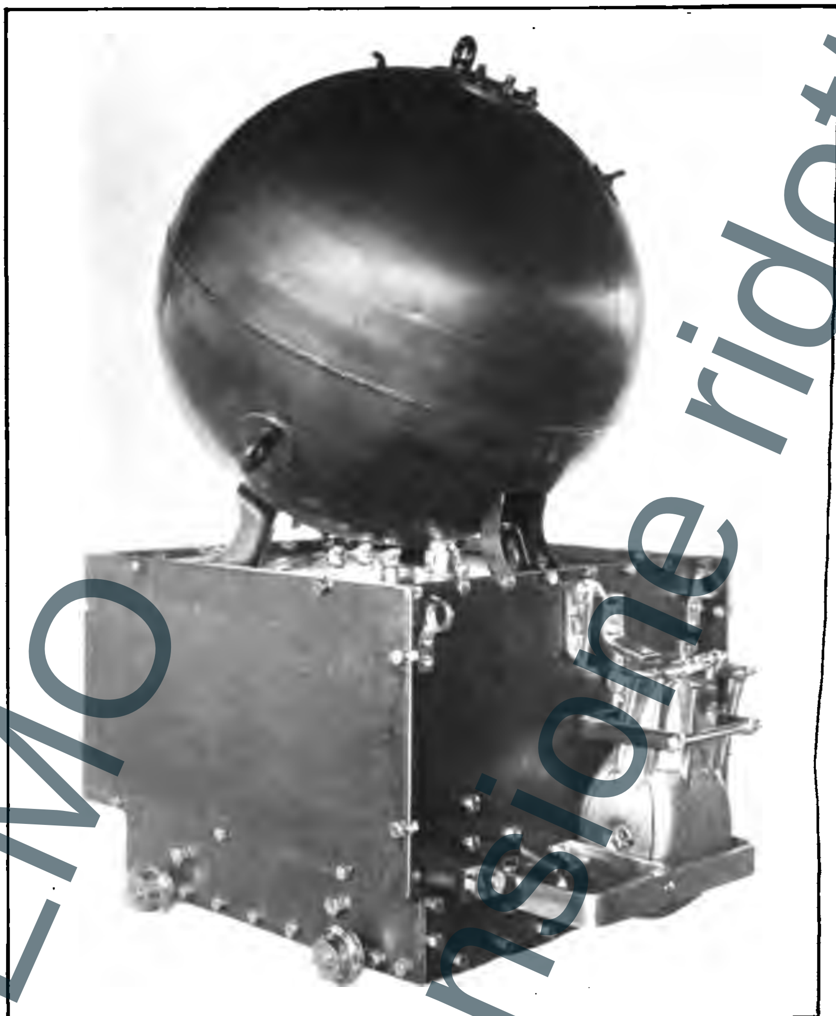

THE MARK VI MINE FITTED ON ITS ANCHOR.

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proceed with the procurement of 100,000 of the new mines, the number which he had estimated would be required.

During the latter part of October it was learned that the British Admiralty had approved the establishment of a mine barrier between Aberdeen, Scotland, and Ekersund, Norway. It had not been possible to go ahead with plans for the barrage, except in the matter of design and manufacture of the mines, until the British decision was definitely known. The project was formally approved by the Secretary of the Navy, shortly after the British approval was confirmed; and, on the following day, October 29, it was favorably acted upon by the President at a Cabinet meeting.

The Bureau of Ordnance at once proceeded with the design and procurement of the required mining material, and 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 the design of the new mines, launch the huge manufacturing project, and obtain production in adequate quantities, not later than February.

Although the Northern Barrage plans, as adopted, provided for the line to extend from Aberdeen to Ekersund, it was later decided to change the location of the barrage, so that it would extend from the Orkney Islands to Bergen, Norway; and it was on this latter line that the barrage was actually laid[1].

This change was really made so that the mind of the Commander in Chief of the Grand Fleet would be free from worry as to mines, in that he could operate anywhere in the North Sea from Scapa southward without passing through the barrier, as would not have been the case had the original line—Aberdeen to Ekersund—been adopted.

## II.—DESIGN, MANUFACTURE, AND SHIPMENT OF MINES.

The two principal parts constituting a mine are the mine sphere and the mine anchor, which are held together until dropped from a

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[1] Extract from "The Grand Fleet, 1914–16—Its Creation, Development, and Work," by Admiral Viscount Jellicoe, p. 250:

"In 1917, shortly after my return to the admiralty, I undertook a very extensive mining policy. In the previous year, during Sir Henry Jackson's service as first sea lord, a new and much improved mine was designed, the trials of which were carried out after I relieved him. This was one of the replies to the submarine. One hundred thousand of these mines were ordered by me early in 1917 to carry out various schemes. Later in 1917, with the assistance of the United States, provision was made for the large mine field across the North Sea, known as the Northern Barrage. It was not until the large supplies of mines became available in the autumn that really effective results against submarines by mining began to be achieved, although the operations of German surface vessels had previously been hampered to a very considerable extent."

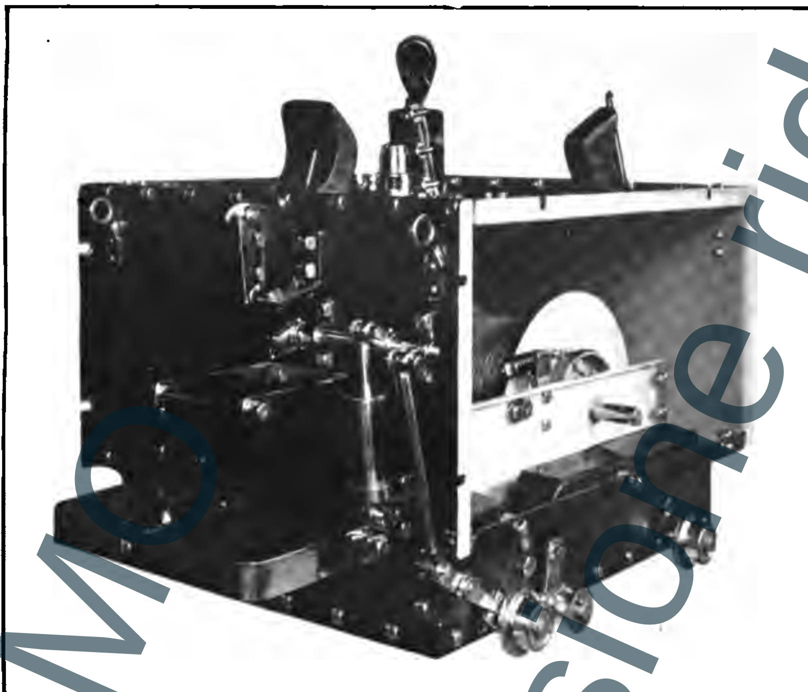
As a matter of fact, the United States Navy by its insistence and perseverance in the project caused the Northern Barrage to be laid, and for this barrage supplied more than sufficient mines. In fact, of the 70,263 mines laid there were 56,611 planted by the American Mining Squadron, all being American mines.

mine layer. The mine sphere, in addition to containing the explosive charge, comprises all the firing mechanism and the safety arrangements. Contained within the mine anchor, or attached to it, is all the mechanism for mooring the mine. The total weight of the United States type mine and anchor, when assembled, is 1,400 pounds, of which the explosive charge, TNT, is 300 pounds.

At the time the barrage project was finally adopted, the firing mechanism and the mine case were the only parts of the Mark VI mine that had been completely designed. One reason for this was that there was insufficient information with which to proceed with the other points of design, until the firing mechanism was conclusively tested and adopted. Also, until the adoption of the project, there was insufficient personnel in the Mine Section of the bureau for such a large undertaking. The problem confronting the bureau was building a mine around an entirely new principle in mining. This mine had to be efficient, and yet capable of manufacture and assembly in great quantities. The usual mine had been departed from in the new firing gear, and radical developments were then made in the entire mine.

In view of the fact that there were so many uncertainties entering into the design of the mine, it was decided to design it in such a way that modifications of any one feature could be made without detriment to the others. To this end the parts of the mine were divided into groups, each group being quite a separate design problem, and all parts were so standardized that the several groups would assemble into a complete mine. In other words, every 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 they functioned as designed, and only very minor improvements involving no delay in the project were found to be desirable or necessary.

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 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 it would not be necessary to have it manufactured as a unit, and its many parts could be manufactured in commercial plants with great rapidity. The desired production was 1,000 mines a day, and it was believed that this number could be obtained.



VIEW OF A U. S. MINE ANCHOR, SHOWING THE MOORING CABLE WOUND ON ITS DRUM.

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VIEW IN CONTRACTOR'S PLANT, SHOWING NEARLY COMPLETED MINE ANCHORS ON RAILS READY FOR INSPECTION AND ADJUSTMENT.

Secrecy regarding the characteristics of the mine was also preserved by having a large number of plants manufacture the mine. 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 will have sufficient information to visualize the complete mine, and, therefore, no one can 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. 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 the mine, or protecting himself against it, within, say, a year after he gained knowledge of it, by which time it was expected that the war would be over.

Another factor entering into the design of the mine was the decision to issue the mines as "fixed ammunition"; that is, to have the mines practically ready to lay when taken aboard the mine layers. It had been the practice in all navies to make numerous tests and adjustments shortly before laying, and this necessitated a large and skilled personnel aboard the mine layer. While this principle of "fixed ammunition" was a radical departure from previous practice it was possible, after it was accepted, to design, manufacture, and inspect the mine accordingly. It is believed that it had much to do with the success of the operation, since, without it, it might not have been possible to prepare the mines rapidly enough to permit of completion of the barrage.

The personnel engaged upon the design of this mine included many officers of the bureau. Initially Commander Fullinwider assumed charge of the design of the mine case and the mine anchor, while Lieut. Commander Wilkinson supervised the designs for firing gear, explosive, and safety arrangements. As the work increased, Commander Fullinwider remained in charge, but distributed the duties of design as follows: To Lieut. Commander O. W. Bagby, United States Navy, and Lieut. S. W. Cook, R. F., the mine anchor; to Lieut. Commander J. A. Schofield, R. F., the mine case; to Lieut. Commander W. A. Corley, United States Navy, the external appliances of the mine case; and, under Lieut. Commander Wilkinson, to

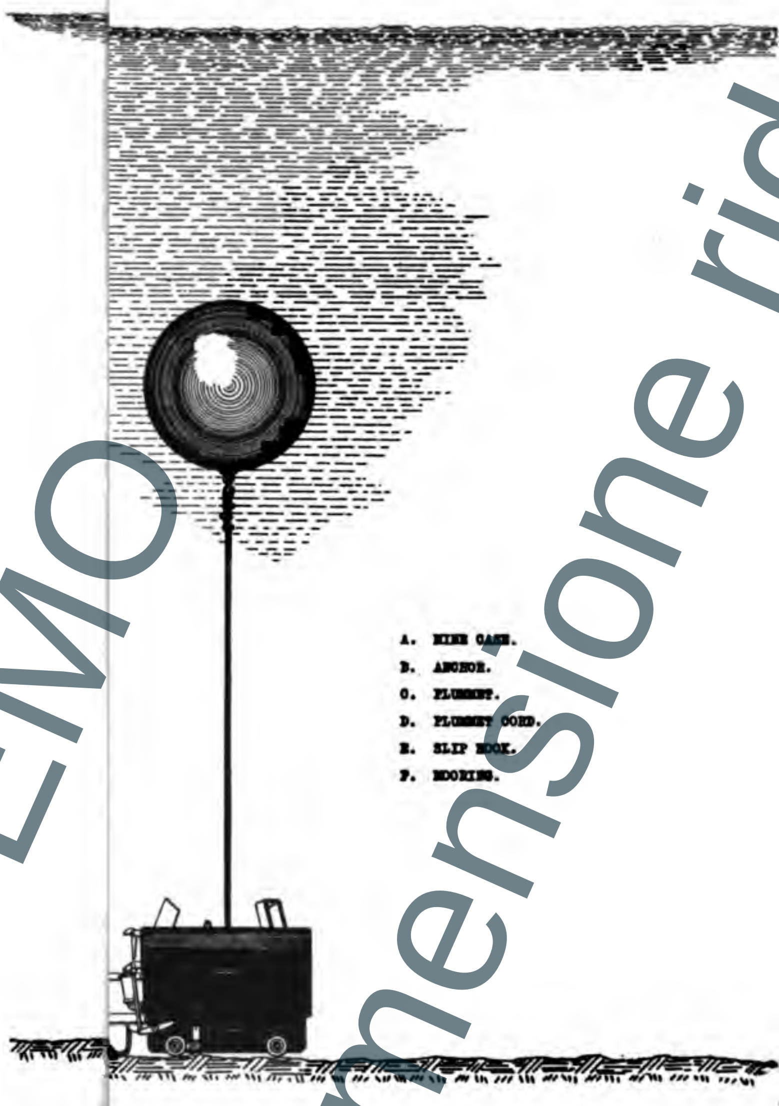
Lieut. Commander C. H. Wright, United States Navy, the firing gear; and to Lieut. (Junior Grade) B. W. Grimes, R. F., the explosive. Lieut. Commander H. E. Fischer, United States Navy, acted as executive assistant to Commander Fullinwider. These officers assumed charge of the particular parts noted, and followed their manufacture in accordance with the general bureau organization plan throughout the stages of production, inspection, and delivery. Lieut. Commanders Bagby and Wright subsequently were ordered to duty at the mine bases abroad.

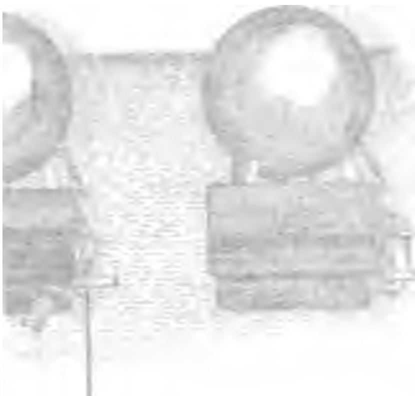
The actual drafting and detail design work for a large share of the mine parts was done in the bureau's drafting room. The bureau's technical drafting force comprised but three draftsmen, Richard R. Bright, Carl F. Weller, and Charles R. Burr, upon the outbreak of the war. The need of close daily and hourly contact with the bureau's officers and its drafting force, and with the other technical bureaus of the Navy, could not be met by the Naval Gun Factory's design force, and so Lieut. Commander G. L. Smith (ret.) was detailed in charge of the bureau's force, which was augmented quickly to some 31 persons, including experienced ordnance designers. The main portion of the detail drafting and design for ordnance still continued at the gun factory, but the bureau developed mines, mine-firing devices, nets, depth charges, mine anchors, and many other devices.

The Mark VI mine case was formed of two hemispheres of steel welded together at the equator. The firing mechanism was contained in a central tube, extending along the axis of the case. A radical departure from the usual practice was the omission of a separate chamber in the mine case for holding the explosive. The disadvantages of this extra chamber were that it gave additional weight, thus detracting from the buoyancy of the mine; that more time and money were required in manufacture, loading and assembly; and that, most serious, the interposition of an air cushion surrounding the charge chamber, between the first explosive force and the water, greatly reduced the force of the hammer blow caused by the explosion, which is relied on to destroy the vessel firing the mine. These difficulties were obviated by selecting an explosive which could be readily cast and cooled, and casting this directly into the completed mine case. The charge was kept in place by the four stay braces, which supported the central tube; this form of construction permitting of the mine case being kept within comparatively small dimensions, 34 inches in diameter.

The explosive in the Mark VI mine was 300 pounds of trinitrotoluol (TNT). Trinitrotoluol is but slightly inflammable and, if ignited, burns only with difficulty. It is the least sensitive to shock of all known high explosives. This explosive is perfectly im-

FIG 6


A. MINE CASE.
B. ANCHOR.
C. PLUMMET.
D. PLUMMET CORD.
E. SLIP HOOK.
F. MOORING.



permeable to water and, if necessary, could be submerged for years without losing its aptitude of detonation in the least degree. It was for these properties, which make it excellent for submarine mines, that TNT was selected.

The Mark VI mine was designed to be very safe in handling. That this object was attained is well demonstrated by the fact that 85,000 of these mines were shipped abroad and 56,611 of them were planted in the barrage, all without accident.

For instance, a safety point to which careful attention was given was to insure that, in the event of a premature explosion of a mine, it would necessarily occur only after a safe interval after launching. It had previously been the practice to have the detonator—the most sensitive element in a mine—fixed in the explosive. This was a source of danger, in case of accident or fire, or in case the mine layers were engaged in action with mines on board. The Bureau of Ordnance demonstrated by experiments that if the detonator were kept away from the explosive charge the mine would not be fired, if the detonator should accidentally explode, and the only result would be rendering the mine dead, or, in other words, "a dud." With the device adopted for the Mark VI mine, the detonator is not in contact with the main explosive until after the mine has been launched and submerged to a depth of 30 feet. Again, a similar hydrostatic 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 necessity for getting the mine anchor into quantity production as soon as possible did not permit of time being taken for development of an entirely new anchor with the necessary experiments. As a result of experimental work carried on since the beginning of the war the British had an automatic anchor (called the Mark VIII sinker) which was giving satisfactory results. It was believed that this anchor could be adapted to the Mark VI mine. The Mark VIII British sinker was, therefore, the basis of the design of the Mark VI anchor, and such modifications were made as were necessary under the direction of Lieut. Commander H. Isherwood, R. N. V. R., an able mine-design officer attached to the bureau through the courtesy of the British Admiralty. The Mark VI anchor differed 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 safe to proceed with production. The anchor proved most satisfactory in every respect.

The anchor is a generally rectangular box of steel plate, about 2½ feet square and 2 feet high, and weighs approximately 816 pounds.

The mooring cable, wound on a drum, is contained within the anchor; and a plummet, containing the plummet cord, is hooked on one end.

The action of the anchor, after it is launched, is illustrated. The plummet is released a few seconds after the mine and anchor strike the water; and when it reaches the end of its cord it releases the mine from the anchor. As the anchor descends, the mooring cable unwinds, until the plummet strikes bottom, when the mooring cable drum is locked and no more cable allowed to unwind. The descent of the anchor then causes the mine to be drawn under the water, so that when the anchor rests on the bottom the mine is moored beneath the surface a distance equal to the length of the plummet cord.

Practically all the contracts for the Mark VI mine were placed after competitive bidding. As a result of the keen competition obtained, and also because quantity production was followed throughout, the cost of this mine was far less than that of similar products before the war, notwithstanding the prevailing high cost of labor and material. There were, in all, 140 principal contractors, and over 400 subcontractors.

The first contract placed was for the firing mechanism. The favorable outcome of the proposal for a barrage had been anticipated, and the contract for 100,000 firing devices had been placed on October 3, 1917, nearly a month before the project was definitely adopted. The firing mechanism, while referred to as a unit, was, as a matter of fact, subdivided into its component parts, and manufactured by more than a score of different factories as subcontractors.

The mine case was the next part of the mine to be contracted for, contracts being placed with five companies the latter part of October.

The manufacture of 100,000 mine anchors was such a big proposition that it was decided to call a conference of manufacturers to see if the desired production could be obtained. This conference of manufacturers was held at the bureau November 10, 1917. Representatives of 42 companies were present, all ready and willing—from the larger concerns, anxious to undertake the entire contract, to the small companies desirous of helping by making some of the small parts—to cooperate to the best of their ability. There are over 100 different parts in the anchor, exclusive of bolts, nuts, washers, and rivets. These parts are made from sheet steel, stamped and pressed, forged steel, cast iron, bronze, brass, and even wood. The assembly of all these parts, on a quantity basis, presented a difficult problem. Motor-car makers, of which a number were represented at the conference, are specialists in assembly, as this is one of their chief problems in obtaining quantity production; and it was apparent that they were best fitted for the major contracts, which would include the assembly of all the parts. It is believed that the Bureau

MINE SQUADRON 1 PLANTING MINES SEPTEMBER, 1918.

U. S. S. SAN FRANCISCO, FLAGSHIP OF COMMANDER, MINE SQUADRON_1.

ENEMY SUBMARINE SIGHTED. ESCORTING DESTROYERS BEGIN A SMOKE SCREEN.

SMOKE SCREEN COMPLETED.

TESTING SMOKE BOXES AT HINGHAM, MASS.

The great volume of dense smoke given off from a number of these boxes enables a vessel to change course unseen by a chasing submarine and make good her escape.

132-1

NIGHT PHOTOGRAPH OF A STAR SHELL BURST.

These projectiles are fired behind the enemy craft, whose silhouette becomes plainly visible.

basic principle of sound ranging, which was later used successfully on the western front, was set forth briefly but clearly by one writer.

One very valuable device was suggested by Mr. Ralph C. Browne, an electrician of Salem, Mass. As originally submitted, this device was incorporated in the design of a submarine gun, which examination showed to be wholly impracticable. The value of this device for other uses, however, was immediately recognized by the officers of the bureau, and, upon their request and much urging, Mr. Browne collaborated with the bureau's experts in developing into a practical form and adapting the device for use in the mines which were being developed for use in the Northern Barrage.

After the entry of the United States into the war, the board was naturally keenly interested in all devices that had to be developed to combat the submarine menace, which soon reached its most acute stage. It took part in the successful development of efficient depth charges, aerial bombs, mines, nets, and smoke-producing apparatus, each of which devices played its part in combating the submarine activities of the Central Powers.

The board also investigated the ballistics of the German long-range gun, and outlined the characteristics of a similar gun, should the bureau become convinced of the utility of such a weapon.

In 1914, a radical departure in the method of gun construction was brought to the attention of the bureau by Mr. A. H. Emery of Glenbrook, Conn., which, at that time, the bureau was unable to accept. In March, 1917, this method was again presented to the bureau by both Mr. Emery and Prof. P. L. Bridgeman, of Harvard University. The bureau then undertook experimentation in the matter. This method produces initial tension in the outer layers of the gun, and initial compression in the inner layers, by fluid internal pressures, of such magnitude as to stretch tangentially all layers, except the outermost, beyond their elastic limit. This process, known as the radial expansion process, produces the same result as would be obtained by the shrinkage process, applied to a gun consisting of an infinite number of infinitely thin tubes. After thorough investigation and considerable experimentation, the board was convinced of the superiority of this process over the shrinkage process, and recommended its general adoption.

The board also devoted considerable time to the development of new high explosives, as there threatened to be a serious shortage of the raw materials used in the manufacture of the high explosives already developed and adopted.

It is still striving to develop a new motive power for torpedoes, with a view to increasing their range and speed, and is also engaged in a very carefully prepared scheme of experimentation and investigation, intended to discover the causes of dispersion, especially at long ranges, and thus make possible an increase in the accuracy of naval ordnance.

During the early stages of the war, the special board was composed of Rear Admiral R. R. Ingersoll, United States Navy (ret.), and Commodore S. J. Brown, professor of Mathematics Corps, United States Navy. Later Rear Admiral S. A. Staunton (ret.) and Rear Admiral N. E. Mason (ret.), a former chief of the bureau, Capt. B. B. Bierer, and Capt. J. V. Chase reported for duty on the board. The experimental officer of the bureau, Lieut. Commander T. S. Wilkinson, performed additional duty as member of the board.

## B.—EXPERIMENTAL SECTION.

Appreciating that the duties of maintaining a supply of ordnance equipment too often precluded, on the part of the material desks of the bureau, continued attention to experimentation in the development of new weapons, the bureau created an experimental section in July, 1916. This section was initially charged with the development of an antisubmarine aeroplane bomb and of other experimental ammunition.

As the war broke and the problem of the submarine became not merely academic but actual and vital, experimentation was carried on with many types of antisubmarine weapons, such as depth charges, mines, smoke screens, and explosives for mines. The services of naval stations such as the Naval Proving Ground, the Naval Torpedo Station, the Naval Gun Factory, and the several navy yards were utilized in preparing the material for and in carrying out such experimentation. In addition, a number of private and public laboratories, in particular the splendid organization of the American University laboratories of the Bureau of Mines and later under the Chemical Warfare Service, were called upon for assistance.

Some of the experimental developments of the bureau during the period of the war are noted.

The first design of depth charge was developed in February and March, 1917, a contract being let to the Sperry Gyroscope Co. for the production of 10,000 charges of this design. These were soon in production and were issued to the Service shortly after the beginning of the war. This type of depth charge was comparatively small, as it contained only 50 pounds of TNT, and it was later replaced by depth charges with a firing mechanism of a new and dissimilar type, carrying heavier charges, which gave a greater radius of effectiveness. The story of the development of the present type was related in Chapter VI.

A design of floating mine, prepared by the Naval Torpedo Station, Newport, R. I., was perfected and a suitable supply (4,000), manufactured and loaded at that Station, was issued to the Service.

SMOKELESS POWDER FIRED AT NIGHT.

Compare this with the photograph of firing of flashless powder from the same gun.

134-1

EXPERIMENTAL FIRING AT NIGHT WITH FLASHLESS POWDER.

This shot gave a small flash, otherwise it would not have recorded on a photographic plate.

134-2

The depth charge is essentially a weapon for "hunting" craft or light escort vessels, such as destroyers. It is not suitable, except as a weapon of opportunity, for heavy ships such as battleships, cruisers, troop transports and cargo carriers. Their defense depends upon proper escort, ability to maneuver away from danger, and effective use of gunfire. Therefore, it obviously became necessary to provide their guns with shell which would not ricochet on first impact with the water, but would dive and burst under water, thus giving some measure of effectiveness against a submarine, which might be submerged and showing only a periscope as a point of aim. Experimentation with various types of nonricocheting shell led to the development of the present standard F. N., or flat nose, shell as the best type of nonricocheting shell for use against submerged submarines, and these were supplied for the various calibers of torpedo defense guns.

In May, 1917, the bureau took charge of the preparation of smoke apparatus. The effectiveness of this apparatus had been shown by a number of instances in which vessels, menaced or attacked, had been able to maneuver out of danger behind smoke screens laid between them and the enemy submarines. The bureau secured specifications from the British of their standard type of smoke apparatus and later procured a supply of this apparatus, and issued the same to the service, later in the summer of 1917. This consisted of the smoke funnel, Mark I, employing phosphorus, and the Mark I smoke box. Both of these types are now obsolete, but did good service pending the development of superior types. The bureau issued 300 Mark I smoke funnels and 6,400 Mark I smoke boxes.

From information received from abroad, and from original research by the American University Experiment Station, under the direction of the experimental section, the Mark II smoke funnel and Mark II smoke box, now standard, were developed and issued to the Service. The new smoke apparatus is safer to handle and operate and of greater smoke-producing efficiency than the earlier types. These issues comprised 1,500 Mark II smoke funnels and 9,000 Mark II smoke boxes.

Experimentation carried out with the depth charge thrower known as the Y-gun, a weapon suggested by Mr. A. J. Stone, of the General Ordnance Co., Groton, Conn., led to its adoption for service during the antisubmarine campaign. This, as indicated by its name, is a Y-shaped, double-barreled gun from which two depth charges are projected simultaneously on opposite sides of the ship. By its use, in connection with the usual launching devices at the stern, a vessel can lay a simultaneous barrage of depth charges, capable of damaging a submarine anywhere within the effective area. The bureau issued to various types of vessels 947 Y-guns.

In April, 1917, experimental development of a new type of mine-firing device was begun under the direction of Commander Fullinwider of the Mine Section, with the cooperation of the Experimental Section. This led to the adoption, in the fall of 1917, of the Mark VI mine, which was of a type especially suited for use in an antisubmarine mine barrage. The use of this mine has been described in the chapter on the northern barrage.

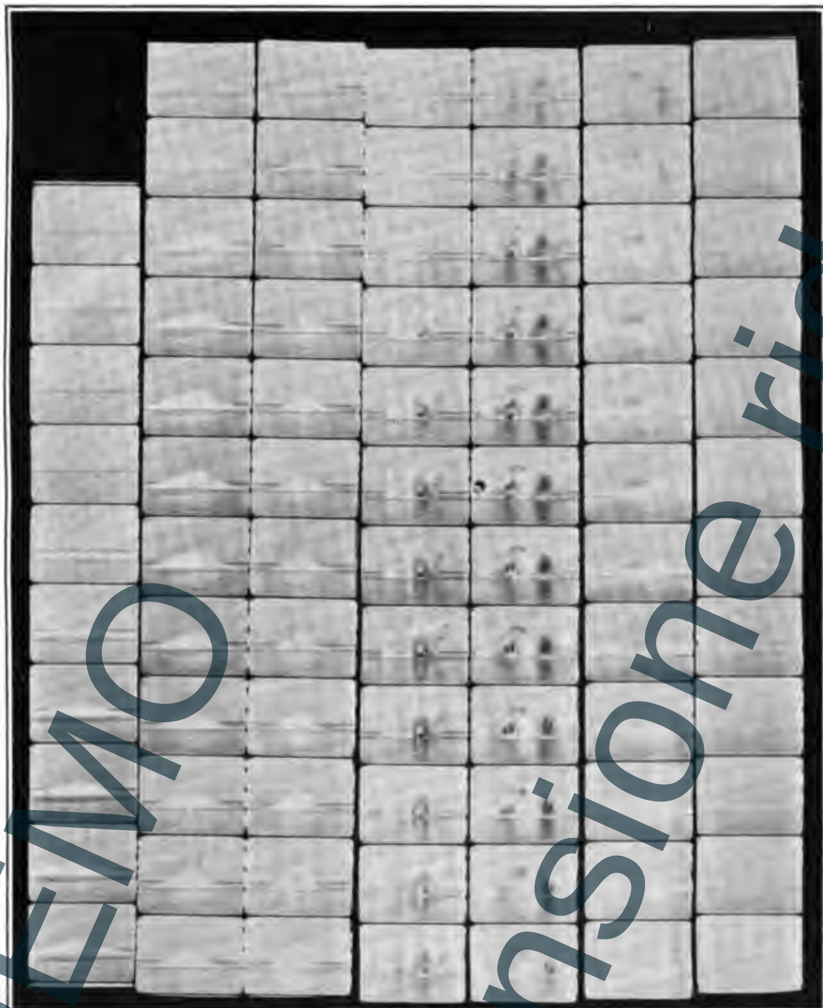
The development of aero bombs, begun before the war, was carried on. The Mark III bomb, carrying 50 pounds of explosive, was improved and issued to the Service in the fall of 1917. The development of Mark IV and V aero bombs followed rapidly. The Mark IV and V bombs were similar, except in the amount of explosive charge carried. The Mark IV bomb carried a charge of 120 pounds and the Mark V bomb a charge of 220 pounds. The firing mechanisms of service aero bombs were also improved. A total of 15,000 aero bombs was issued to the Service. The major work in the development of these fuses was performed by Messrs. L. S. and J. S. Clarke, of Ardmore, Pa.

An antiaircraft high explosive shell, with a time detonating fuse therefor, was developed and put into production.

Based initially upon information received from the British Admiralty, illuminating shell, or star shell, for 3-inch, 4-inch, and 5-inch guns were designed and production begun. These shell are capable of being used in the high pressure, high velocity Navy guns and are effective at long ranges.

The first experimentation with these shell was by the Germans in 1886; the French starting in 1902, the British in 1909; the Italians and Belgians in 1910, and the United States in 1912. The problem is a difficult one and a really reliable satisfactory shell for high-powered guns did not exist. Among other experimenters, the Pain Fireworks Co. have labored for six years unsuccessfully. Then, too, some 840 inventors have tried without result. Early in March, 1917, the Bureau of Ordnance started intensive work with the problem. The shells developed and fabricated are quite satisfactory. The naval ordnance plant at Baldwin, Long Island, taken over, together with the company's development work, from the Ordnance Engineering Corporation, of New York, was put in operation entirely for the production of shells of this type.

As illustrating their use, on March 21, 1918, two British and three French destroyers were engaged with a force of German destroyers in the vicinity of Dunkirk. The allied forces were aware of the proximity of the German destroyers because of the latter's fire upon Dunkirk. Steaming toward the Germans, the allied destroyers fired star shell to obtain the range. The Germans then ceased firing and fled, and the night being misty, they were soon



MOVING-PICTURE FILM OF UNDER-WATER EXPLOSION OF A MINE, SHOWING DEVELOPMENT OF WATER COLUMN.

136-1

FRAGMENTATION OF LANDING GUN HIGH-EXPLOSIVE PROJECTILE, USING SEMPLE MODIFIED FRANKFORD ARSENAL DETONATING FUSE.

136-2

U. S. NAVY HYDROPLANE HANGAR.

140-1

9-POUNDER DAVIS GUN AND LEWIS MACHINE GUN ON BOW OF FLYING BOAT.

140-2

DAVIS AND LEWIS GUNS ON BOW OF FLYING BOAT.

140-3

N-1 SEAPLANE. DAVIS AND LEWIS GUNS IN POSITION.

allowing the empty casings to escape. This was very dangerous, if the gun was in front of the propeller on the plane, as the empty casings would ruin the propeller, with a consequent likelihood of the pilot being struck by fragments of the propeller or by the casings themselves. A new deflector was supplied, which has a much larger bag securely riveted to the chute with a metal distender on the inside.

The Lewis gun not being suitable for fixed gun work in synchronized firing through the propeller, an order was placed in September, 1917, with the Marlin-Rockwell Corp. for 1,000 Marlin aircraft guns, which had proved satisfactory in synchronizing tests at the Marlin-Rockwell plant. When production was commenced on these guns, numerous minor mechanical faults developed, and deliveries were held up until July, 1918, since which time the contract has been completed, and the few guns that have been issued to the naval service have been the subject of favorable report.

A heavy water-cooled Browning machine gun used by the Army was adapted for air use by removing the water jacket and lightening the interior part of the mechanism. It has a firing speed of approximately 1,000 shots per minute and uses either the hemp or the disintegrating metal belt feed. It is suitable either as a flexible or as a fixed gun, synchronized with the engine. The Navy had ordered 100 of these guns from the Army, but they were not put in service before the armistice was signed. The demand for fixed, synchronized guns for naval use has been very small owing to the type of aircraft in use.

For the flexible gun mounts used with Lewis guns, the scarff ring mount, as originated by the British and adopted by the Army, was found satisfactory and accepted as standard. This mount was procured from the Army in adequate quantities and in time to meet the gun production. It became standard equipment for the front cockpit of all flying boats. Mounts for two Lewis guns, and outrigger mounts for the side openings in large flying boat hulls, were designed and produced to meet the production of those boats.

For anti-submarine warfare, the need for a large caliber gun with sufficient power to penetrate the hull plating of a submarine, either on, or slightly below the surface, was strongly felt and the Davis non recoil gun was produced and mounted for that purpose. This gun is a radical departure from previous types of gun, in that the barrel is open at both ends, and is loaded at the center by rotating half of the barrel around an off-set axis. The projectile leaves the front barrel in the usual way, while a rear charge of equal weight is projected from the rear barrel. The force of the explosion of the charge is taken up by the reaction between the projectile and the rear charge, and no recoil force is transmitted to the mount. In the early form of this gun, a rear charge of bird shot and vaseline is used, while in the later model a steel cartridge case is itself projected to the rear, leaving the bore clear for the next load. Suitable stops prevent the rear barrel being depressed sufficiently to endanger the upper wing of the airplane.

In place of the usual form of sight, a Lewis gun is mounted above the Davis gun barrel, at such an angle that the Lewis gun bullets and the Davis gun shell will strike the water at the same point from the usual height of patrol (about 1,000 feet). In aiming the gun, bursts from the Lewis gun are fired in approaching the target, and the Davis gun is fired when the Lewis gun splashes near the mark—a double trigger facilitates this action.

As an example of the possible value of such a weapon, an incident which occurred off Wexmouth, England, in the latter part of September, 1918, may be cited. A patrolling seaplane sighted a submarine with its periscope exposed and failed to damage it with the two bombs carried by the plane. No reply was received to radio messages sent by the plane and the submarine finally escaped, after remaining near the surface for an hour and a half, probably because her diving rudders had gone out of commission. Had a seaplane armed with a Davis gun been present the destruction of the submarine would have been assured:

The types of large flying boat used for anti-submarine patrol in this country were fitted to carry this gun, but none had been sent abroad up to the time of the armistice.

Development of a 37-mm. automatic cannon, for use both as a motor gun, firing through the hub of the propeller, and as a flexible gun on a mobile mount, was undertaken, as was a 3-inch gun for use in the large type of dirigibles. Samples of foreign aircraft cannon were obtained and tests with them, and with various types of ammunition, were made in cooperation with the Army. None of these had passed the experimental stage at the time of the armistice.

During the months of October and November, 1917, a great deal of time was spent in gathering information as to gun sights, particularly those regularly in use abroad. The two sights which stood out prominently and which seemed most desirable were the Aldis unit sight and the wind vane and ring sight. The latter was particularly adapted for mobile guns and the plan was to employ such sights for mobile guns and the unit sight for fixed guns.

The wind vane sights used abroad were of the so-called Norman pattern and our Army, at this time, was negotiating with contractors to copy this sight. Investigation showed that one contractor in particular had proposed an improvement of the Norman pattern sight, looking toward a more sturdy design and the elimination of lost motion. The bureau immediately encouraged the efforts of this

LOADING THE DAVIS GUN

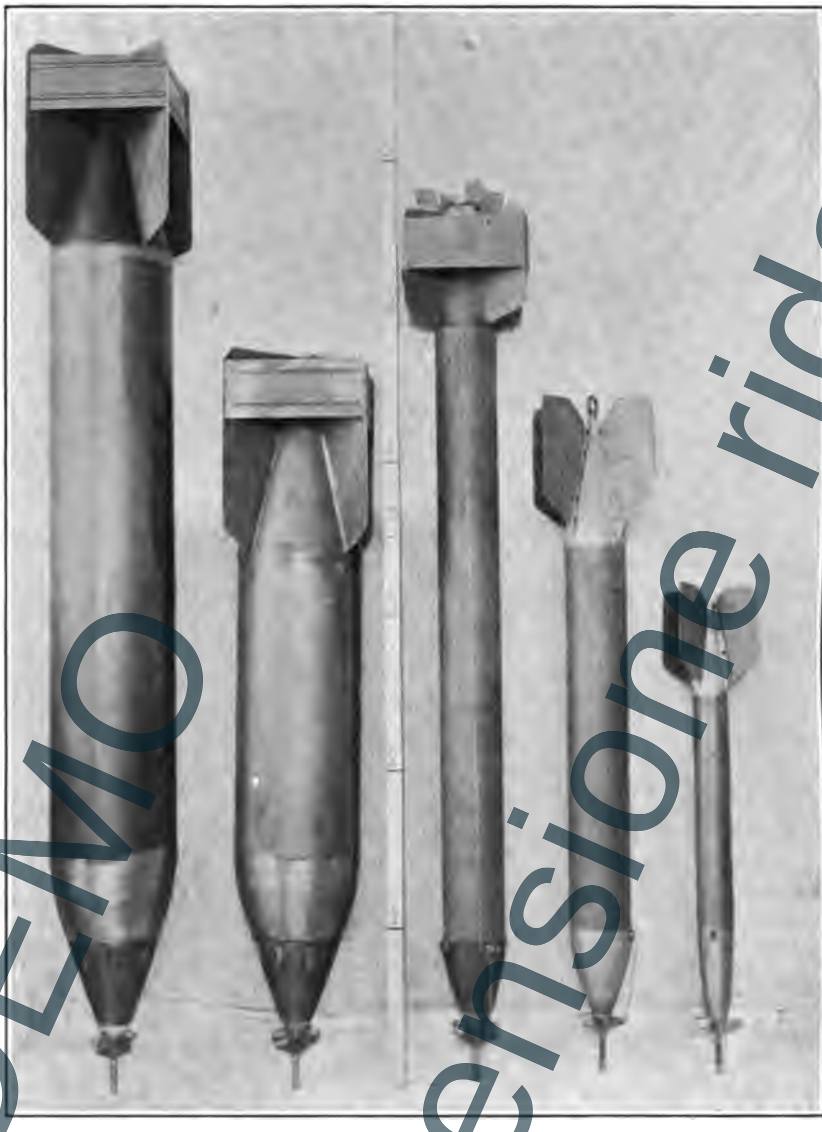
142-1

LEWIS GUN, TRIPLE MOUNT.

142-2

BOMB AND BOMB-GEAR INSTALLATION ON SMALL FLYING BOAT.

142-3



DIFFERENT SIZES AND TYPES OF UNITED STATES BOMBS.

142-4

contractor, models were made promptly and tests conducted in December, 1917, and production entered into so that the first shipment of Lewis guns abroad, about February 1, 1918, was accompanied by these new sights. Those sights have been used since with all Lewis guns, with uniform success.

The wind vane sight acts as the fore sight and compensates for the velocity of the bullet due to the movement of the gunner's craft. The rear sight is a so-called ring sight designed to allow for the speed of the enemy craft.

These ring sights, as used abroad and as adopted by the Army, comprised a center peep and a single ring calculated for a 110 miles per hour speed of the enemy. The bureau, however, designed a new ring sight comprising two rings in addition to the center peep, one of these rings being calculated for an enemy speed of 100 miles per hour and the other for an enemy speed of 130 miles per hour, the purpose being to present immediately the proper correction for two prevalent speeds and to present a basis from which to interpolate by judgment. These ring sights were furnished commensurately with the wind vane sights, and wind vane sights of various types were furnished, calculated for different speeds of the gunner's craft, all proving entirely satisfactory in service.

Mr. A. H. Woodward, of the contractor company manufacturing these sights for the bureau, becoming familiar with wind vane sights and their operation, designed a so-called "Universal" wind vane sight, which could be adjusted for any speed of the gunner's craft, within adequate limits, thereby intending to eliminate the necessity of providing a number of sights each calculated for a certain speed. This device was worked up to a point of satisfactory performance, acceptance, and production.

Early in the war it became necessary to take special precautions with the inspection and selection of aircraft ammunition for small arms. A system of grading and packing was established which insured a supply of perfect ammunition for aircraft use. New types of bullets were also required, but as these had been in production for the Allies before this country entered the war, no difficulty was experienced in their procurement.

For some time before the war, the bureau had been experimenting with aeroplane bombs. Two types had been developed, suitable for use against troops. These were intended to be used by aeroplanes supporting or operating with naval landing forces on the enemy coast, the aeroplanes to assist in attack on the defending troops.

As the European war progressed, however, it became apparent that aircraft might well be used not only to observe the movements of submarines but to attack them. Submarines on the surface could be seen from aircraft and to varying depths below the surface, dependent on the clearness of the water. Aeroplanes should therefore be equipped with bombs which would explode on contact if they struck the submarine on or below the surface. The effect of an explosion under water in the vicinity of a submarine has been noted in the chapter on "Depth charges." Similarly, an aeroplane bomb, if it failed to make a direct hit on a submarine, might yet cause considerable damage by exploding in the water near the submarine. Accordingly, the bombs should, failing a direct hit, be capable of exploding at a given depth in the water, so that every possible chance of injuring the submarine might be utilized. Therefore the bureau, long before the entrance of the United States into the war, had made numerous experiments to develop such a dual action bomb.

In April 1917, although tests had been made toward the developbent of such a weapon, no bombs of a perfectly satisfactory type had been put into production. Ordnance development was limited by the scarcity of aircraft available for testing out the material. The first bombs tested had been apparently satisfactory, but, on the afternoon of November 8, 1916, off Indian Head, Md., Lieuts. (Junior Grade) Luther Welsh and C. K. Bronson, United States Navy, were killed by the premature detonation of a bomb. This led to improvement in safety features, with the result that no recurrence of this accident was experienced with American-made bombs during the war. By September, 1917, two types of bomb were in service, and a third type of larger size was coming into production.

The bomb-carrying capacity of naval planes became greater as various types were developed, and so the sizes of bombs became larger and their destructive radius greater.

Looking for a moment at the progress made by the British and French in this regard, it was found that the former first considered a 65-pound light case bomb of sufficient size for effective use against the first types of enemy submarines used. As the submarine became larger and less vulnerable to weapons of this type, they found it necessary to increase the size of the bomb to 100 pounds, then to 230 pounds. Later in 1918, they developed a successful bomb 520 pounds in weight and in the meantime had constructed large seaworthy flying boats that were able to carry two bombs of this size or four of the 230-pound bombs previously mentioned.

Following, now, the progress made by the French during the war and up to about the first of 1918, it is noted that they, also, had increased their sizes of bombs at about the same rate as the British.

Their first successful bomb weighed 52 kilograms and contained 35 kilograms of melinite. The next larger size weighed 75 kilograms and contained 50 kilograms of melinite. Their latest and largest type was the 150 kilogram type, with about 100 kilograms of the same explosive.

144-1

ENLISTED MEN OF THE INSPECTION FORCE AT WORK ON AIRCRAFT BOMBS.

COMPLETED BOMBS HUNG FOR PAINTING.

144-2

BOMB AND BOMB-GEAR INSTALLATION BEFORE WING COVERING IS PUT ON.

FLYING BOAT WITH BOMB GEAR, AND DUMMY BOMB IN POSITION.

The increased size and power of flying boats, and the developments noted abroad, all pointed to an increase in the size of the bombs to be carried, and the bureau began the production of bombs weighing 163 pounds with 117 pounds of explosive, and 270 pounds with 217 pounds of explosive.

Shortly after this time, bombs following the British 230-pound model were manufactured and issued, and a third size of the American-made bomb of 216-pound weight was produced.

The early forms of fusing mechanism for bombs of American design did not prove entirely satisfactory in service, due to their not standing storage under the climatic conditions experienced and to the insufficient care that could be given them under service conditions, and so various changes were made tending toward improvement.

When the defects in this fuse, unforeseen either by the company or the bureau, were developed in service use the manufacturers, Clarke & Co., of Ardmore, Pa., turned their efforts to the design of a still better fuse, and in a short time had succeeded in devising and manufacturing what the bureau considers the most satisfactory antisubmarine bomb fuse extant.

In this new fuse, the requirements for safety are met by the fact that the booster charge is kept several inches away from the primer until after the bomb has fallen at least 300 feet. During this fall an air-driven propellor screws the detonator and primer caps along a threaded shaft into contact with the booster. While attached to the plane in flight, this propeller is prevented from rotating by suitable stops. In case it is desired to drop the bomb "dead," a stop is allowed to remain in place and to fall with the bomb. For a "live," drop, this stop is removed as the bomb leaves the bomb gear. Production of these fuses was begun as soon as possible, but they were not available for issue to the service prior to signing of the armistice.

British-type fuses for the British design of bombs as procured by the bureau were satisfactory and were supplied with those bombs. They, however, did not contain all the features that fuses for use against submarines should possess.

All of the types of bombs described were used in submarine patrol work in this country, the forces overseas, in accordance with departmental policy, obtaining their bombs from foreign sources.

At the time of the armistice light-case bombs of 520 pounds weight, for attacking submarines, and three sizes of heavy case bombs for attack on ships and shore stations were under development, and have since been completed and tested.

Smaller bombs for use on land type machines, with which the Navy and Marine Corps gradually became concerned, were obtained from the Army, who were already in production with the several models required.

In March, 1918, what was known as the Northern Bombing Squadron was formed for the purpose of bombing, with land machines, Belgian naval bases occupied by the Germans and used by them as submarine, destroyer, and naval air bases. This work was to be done in conjunction with the British Royal Air Force, which had been effectively bombing these ports throughout the war and which had not only seriously embarrassed the enemy by continual day and night attacks, but was gradually making their positions untenable. To assist the British in these attacks, the American Navy was to bomb by night with Caproni and Handley-Page planes, and by day with the DeH-4 and DeH-9 planes operated by marines.

At the time of the start of this northern bombing project, several thousand of various types of Army bombs were ordered from the Ordnance Department of the War Department. Delay in the manufacturing program necessitated the loading of these bombs by the Navy, and steps were being taken to cover this, when advices from overseas showed that these bombs were unsatisfactory for the Navy's purposes, due to the lack of bomb carriers, and also to the fact that the bomb cases were not sufficiently heavy. The whole program was therefore discarded, and the bombs were turned back to the Army.

In October, 1918, Lieut. Claussen returned from England and France for the purpose of starting production on heavy case land bombs to be used by the above land bombing squadrons. Inasmuch as operations were to be in conjunction with the British, it was decided to produce exact duplicates of British bombs, with a view to making interchangeability of bombs and their components possible.

The following program was laid down and steps taken for its completion:

25,000 112-pound heavy case (28-pounds amatol 40/60.)
10,000 250-pound heavy case (111-pounds amatol 40/60).
5,000 550-pound heavy case (180-pounds amatol 40/60.)

Each of these bombs was to be provided with both a nose and tail fuse and a hanging band for horizontal suspension. The type of nose fuse to be used incorporated a suspension lug, which provided a means of vertical suspension inside the fuselages of Handley-Page and Caproni machines. The same nose and tail fuses could be used, interchangeably, in any of the above bombs.

When hostilities ceased, this program was canceled but 50 each of the 112-pound, 250-pound, and 550-pound bombs were cast at the Naval Gun Factory, in order to carry out tests and to obtain further data on heavy case bombs.

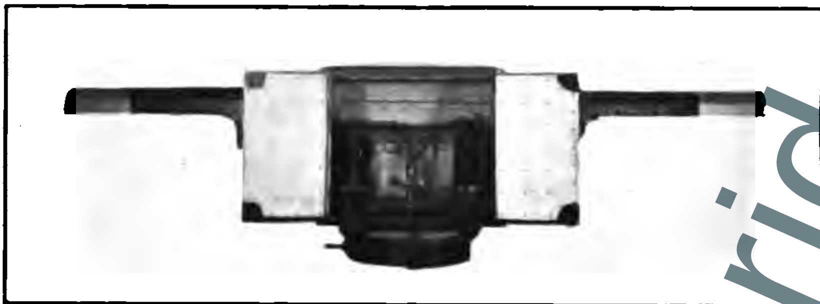
K I BOMB.
FUSES.)

| | |
|---|---|
| ................ | 191 pounds. |
| ................ | 96 pounds. |
| ................ | 37¼ inches. |
| ................ | 12¾ inches. |

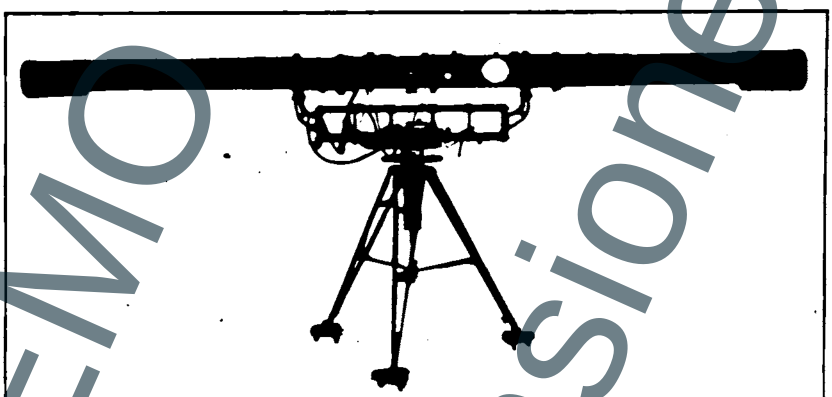
550-POUND MARK I BOMB.
(MARK I AND II FUSES.)

| | |
|---|---|
| Weight of case | 498 pounds. |
| Weight of cast TNT charge | 190 pounds. |
| Length | 62.4 inches. |
| Diameter | 15 inches. |

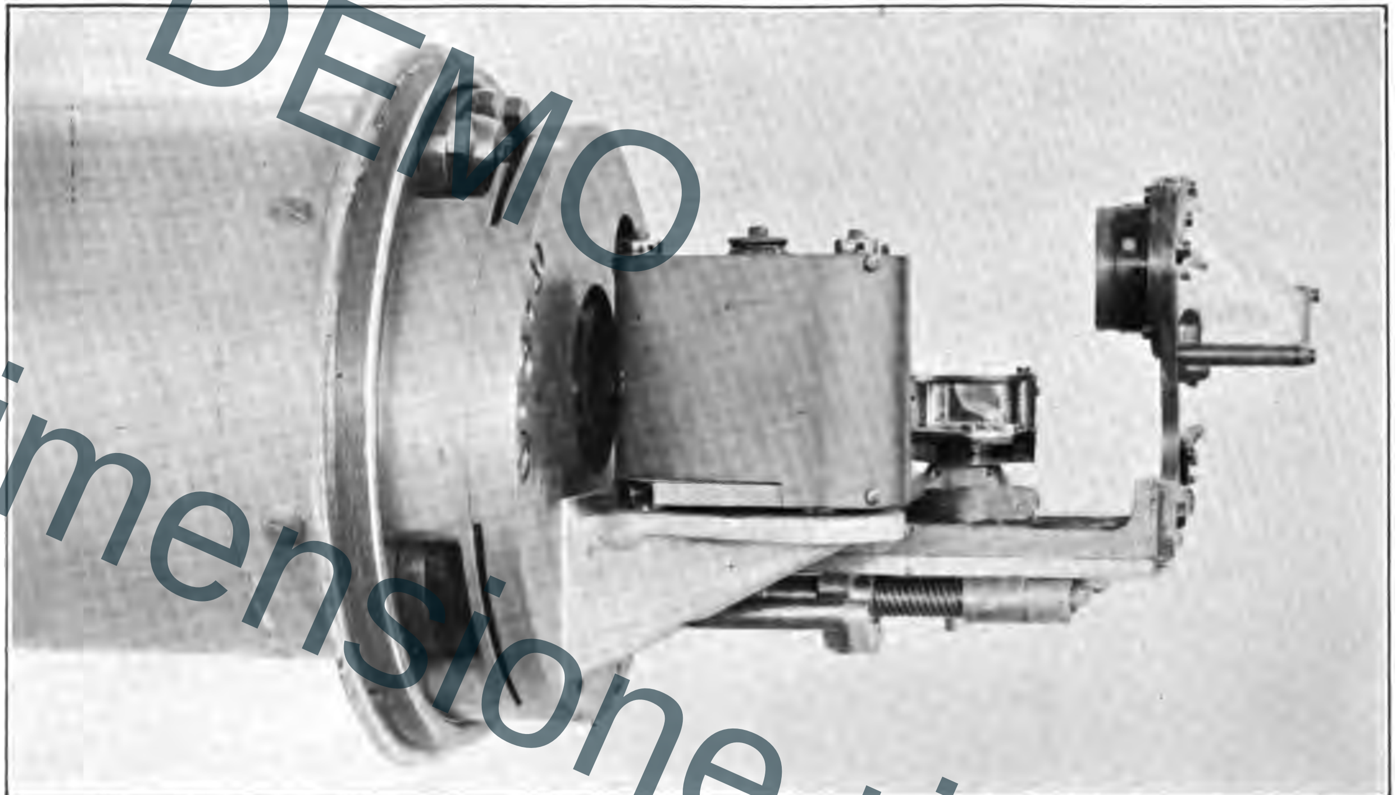
FORD RANGE KEEPER, MARK II, FOR USE WITH TORPEDO DEFENSE BATTERIES AND ON SMALL VESSELS.



INCLOSED RANGE-FINDER STAND FOR EXPOSED POSITIONS.



A 20-FOOT RANGE FINDER ON STAND.



END BOX REMOVED FROM RANGE FINDER, SHOWING MOUNTING OF END PRISMS.

All prisms, lenses, and mirrors must be in exact position, and all mechanical fitting must be within the smallest possible tolerance in order that the instrument function properly.

organization in the fire control section of the bureau about the time of the armistice as follows:

| | |
|---|---|
| Chief of section | Comdr. W. R. Furlong, U. S. Navy. |
| Optics | Comdr. H. A. Orr, U. S. Navy. |
| Aid for optics | Mr. Lawrence Radford. |
| Fire control for battleships and cruisers | Lieut. Commander R. M. Comfort, U. S. Navy. |
| Fire control for destroyers and submarines | Lieut. Commander F. S. Craven, U. S. Navy. |
| Anti-aircraft fire control | Lieut. H. C. Mittendorf, R. F. |
| Range finders | Lieut. Commander A. A. Michelson, R. F. |
| Broadside directors | Lieut. (j. g.) J. J. Lamberty, R. F. |

The foregoing account is, of necessity, only a brief *résumé* of the activities of the fire-control section of the bureau during the continuance of hostilities. It can truthfully be said that the magnitude of the fire-control problem in its various phases, mechanical, electrical, and optical, has increased enormously, both as regards design and production, and it is the earnest hope and expectation of the bureau that it may be able to keep fully abreast of all developments in this difficult field, and indeed serve as a pioneer in the solution of fire-control problems for the Navy.

## CHAPTER XI.

## TORPEDOES.

Toward the end of the last century, the development of the automobile torpedo introduced in the field of offensive weapons a very powerful rival of the gun. The torpedo was at first mounted on small craft known as torpedo boats (which in turn grew to the present-day destroyers), and later was supplied to battleships and cruisers. With the development of the submarine boat, the torpedo obviously became its prime weapon, and it is this instrument, as employed by the German submarine boats, which for a time seemed so near to winning the war for Germany, but which succeeded only in bringing into the conflict the United States and thus eventually terminating the struggle in the defeat of Germany.

The torpedo is essentially a missile, as much as the projectile fired from a gun. The projectile is fired at a high velocity by a heavy charge of explosive from a strong, very heavy gun. The projectile, once in air, continues its flight because of the initial velocity imparted to it in the bore of the gun. The torpedo is discharged from a torpedo tube by a light charge of powder or of compressed air, sufficient only to eject it from the tube. Thereafter, the torpedo propels itself through its medium, water (rather than the air of the projectile), regulating its depth and its steady forward course by delicate instruments contained within its fishlike body.

During the Spanish War, the torpedo had reached only a range of 800 yards with an explosive charge of 118 pounds. In the intervening years, the development of this weapon has been such that the torpedo of this last war held double the charge of explosive and was capable of more than a 10,000-yard range, 18,000 yards in extreme cases.

On the side of the enemy, the torpedo was the most important weapon of naval warfare in this war. On the side of the United States and the Allies, its performance has been disappointing, not because of lack of merit in the torpedo itself, but because of lack of opportunity for its use. The torpedo is primarily designed for use against surface vessels; it runs at a predetermined set depth and attacks most dangerously the thin bottom of warships and of merchantmen. Its very accuracy of depth, however, militates against its efficiency against submarines, for, once the submarine is submerged, his depth is not definitely known and a torpedo fired against him is less efficient and less valuable—particularly since torpedoes will not explode except by actual contact—than a depth charge dropped from above him and exploding when it reaches the depth for which it is set, regardless of whether an actual hit is made.

In this war, however, when submarine dueled against submarine, then the torpedo was the only weapon of both combatants, and here it was that the torpedo found use on the allied side.

Although in the final analysis, but little active work was done by torpedoes in the war, this fact could, of course, not be known in advance; and the bureau was responsible at all times for the complete and proper equipment of our forces, battleships, cruisers, destroyers, and submarine boats, with their full quota of torpedoes, that they might be prepared to use them against enemy surface vessels if the enemy came out to do battle, and against submarines if a favorable opportunity offered.

From the original adoption of the torpedo to the present date, the bureau has endeavored to keep abreast and ahead of the times in torpedo design and supply, and there is maintained by the bureau an extensive system of torpedo manufacture, repair, overhaul, and issue.

On April 1, 1917, the status of torpedoes in the service was as follows:

| | | |
|---|---|---|
| Number assigned to vessels | | 1,040 |
| Reserves: | | |
| East coast | 911 | |
| West coast | 95 | |
| Philippines | 40 | |
| Canal Zone | 10 | |
| | | 1,056 |
| Total number serviceable | | 2,096 |
| Ordered and not delivered | | 2,806 |

The number of torpedoes given above, as in reserve, included torpedoes ready for issue to vessels about to be completed. Prior to and on April 1, 1917, the torpedo station was the center of distribution of torpedoes, all spare parts, replacement units, and all reserve torpedo stock. For each torpedo and torpedo outfit afloat, there was maintained, at Newport, a large stock of spare parts and replacement units. Much of the large manufacturing facilities of the torpedo station was employed in keeping the stock of spare parts and replacement units in sufficient quantity at all times to be ready to meet the demands for them afloat.

SINGLE TORPEDO TUBE, RIGHT SIDE, SHOWING TRAINER'S SEAT AND SIGHT.

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ABOVE WATER, 21-INCH TRIPLE TORPEDO TUBE, FOR USE ON DESTROYERS.

The Naval Gun Factory had only very recently taken up the manufacture of torpedoes, and consequently was never a main source of supply. In the spring of 1917, just prior to the declaration of war, the Naval Gun Factory was asked to speed up production on its existing orders for torpedoes, in order that the Navy might have sufficient torpedoes to carry out a policy which apparently would require a large expenditure of torpedoes afloat. This the gun factory did, but never at any time did this speeding-up of work in any way interfere with the set standard of production, which was maintained throughout the period of the war. The production was increased to approximately one torpedo a day, which meant a very large increase in the torpedo force and organization. The gun factory availed itself of every opportunity to promote all kinds of work relative to torpedoes, for the betterment of the service and in the interest of a more reliable weapon.

The Naval Torpedo Station at Newport, R. I., has long been the central torpedo station of the Navy, where overhaul, repair, and issue of torpedoes are carried on, and where the main supply of spare parts, reserve stock and replacement units is kept. Also, in connection with this station is the only official Government torpedo testing range, which is located in Narragansett Bay, about 4 miles north of the torpedo station. On this range all Government torpedoes are proved, all repaired torpedoes are reranged before issue, and all experimental work in connection with the development of new devices is carried on.

Just prior to and after the declaration of war, the torpedo station was engaged, in conjunction with the E. W. Bliss Co., in the design of a 21-inch torpedo for submarine boats. This problem had been acute for some time past, due to the performance of submarine boat torpedoes, in general, in the Navy, and due also to the peculiar conditions existing in the zone of naval operations, where it appeared that a very reliable and fast short-ranged torpedo could be used to very great advantage.

Another large feature of the torpedo station, Newport, has always been the carrying on of practically all experimental and development work in connection with torpedoes. This, unfortunately, was practically discontinued in the summer of 1917, and all plant facilities were immediately put into operation to expedite the manufacture of new torpedoes. While this policy at the time and under the circumstances was only proper, it has since proved to be undesirable, in that experimental work, which is so vitally necessary to the maintenance of a modern and reliable torpedo, was temporarily dropped in the interest of increased production.

The torpedo station was called upon to furnish the nucleus of the organization and personnel around which was built up the torpedo repair station abroad.

The torpedo station has also always been the training school, both for enlisted personnel and officers. Its facilities in this line were immediately taxed to the utmost upon the declaration of war. This was further aggravated by the fact that the destroyer program was put in advance of all other work, and it is these boats which require the maximum number of skilled personnel. There are two schools at Newport. First, the officers' school, with headquarters on torpedo testing barge *No. 2*. Here officers receive a thorough course in the handling, overhaul and maintenance of torpedoes afloat for war conditions. The course occupies approximately 12 weeks of intensive instruction, which includes the disassembling and assembling of torpedoes, their overhaul and actual firing, which is conducted from this barge in Narragansett Bay. The second school is for the enlisted personnel, for the training of torpedo gunners. This course is somewhat shorter than the officers' course and is confined more to overhaul, assembly, and firing adjustments. The headquarters of this school is ashore on the torpedo station, but two yard craft are fitted with torpedo tubes and other facilities, so that all men under instruction are given ample opportunity to actually run the torpedoes from these ships.

One of the greatest problems confronting the torpedo station in the summer of 1917 and subsequently was the maintenance of a large stock of spare parts, replacement units, and the carrying on of a greatly increased amount of overhaul. In addition to this, the assembly, with the necessary overhaul, of torpedoes, for the use of new boats was a problem of the first importance. However, by very careful planning and forethought on the part of the torpedo station, they were prepared and ready at all times to fill orders for spare parts and replacement units, and were able to maintain in a condition ready for issue a sufficient number of torpedoes to supply all new boats as they arrived.

During the period of the war, large increases in the plant and its facilities were made, these almost entirely in the interest of increasing production and increasing the facilities for the maintenance of an ever-growing stock of spare parts and replacement units.

The E. W. Bliss Co., whose plant is located at South Brooklyn, N. Y., has long been the Navy's main source of supply for the manufacture of torpedoes. They are, as the name implies, the nominal originators of the present standard type of United States Navy torpedoes, known as the Bliss-Leavitt.

On April 1, 1917, there were only 20 torpedoes approaching completion, although there was much material on hand and in various stages of manufacture.

The problem, just previous to and immediately following the outbreak of war, was the placing of contracts for very large quantities of material required for the building program. Large contracts were entered into with the E. W. Bliss Co. immediately after the outbreak of hostilities. Successfully to take up the work on these contracts, which were the largest that the United States Navy had ever let for torpedoes, it was necessary for the E. W. Bliss Co. to immediately take measures to increase its plant and facilities, in order that production might be expedited and delivery of torpedoes in quantity commenced as soon as possible. To this end the Navy Department entered into an agreement with the company, whereby they were to expand their manufacturing facilities by factory extensions which would increase their floor space by approximately 40 per cent. This was to take the form of a new building, and all floor space coming under this agreement was to be devoted in its entirety to the manufacture of torpedoes under pending Navy contracts during the war. The cost of these extensions—about $2,000,000—was advanced by the Government, to be repaid by the company, including interest at the rate of 4 per cent, by proportionate deductions from each final payment on torpedoes when delivered.

The understanding was that, with these plant extensions, the Bliss Co. would increase its output to at least 300 torpedoes per month, commencing in the month of July, 1918. This they never succeeded in doing, the largest month's delivery being in December, 1918, when 150 torpedoes were delivered. The failure of the Bliss Co. to meet its obligations and promised deliveries was, however, largely due to difficulties in obtaining air flask forgings from steel manufacturers.

There is maintained, at the works of the E. W. Bliss Co., a large force of Government inspectors. This organization, at all times, exerted its influence in the interest of increased production and the delivery of a more reliable weapon to the Government.

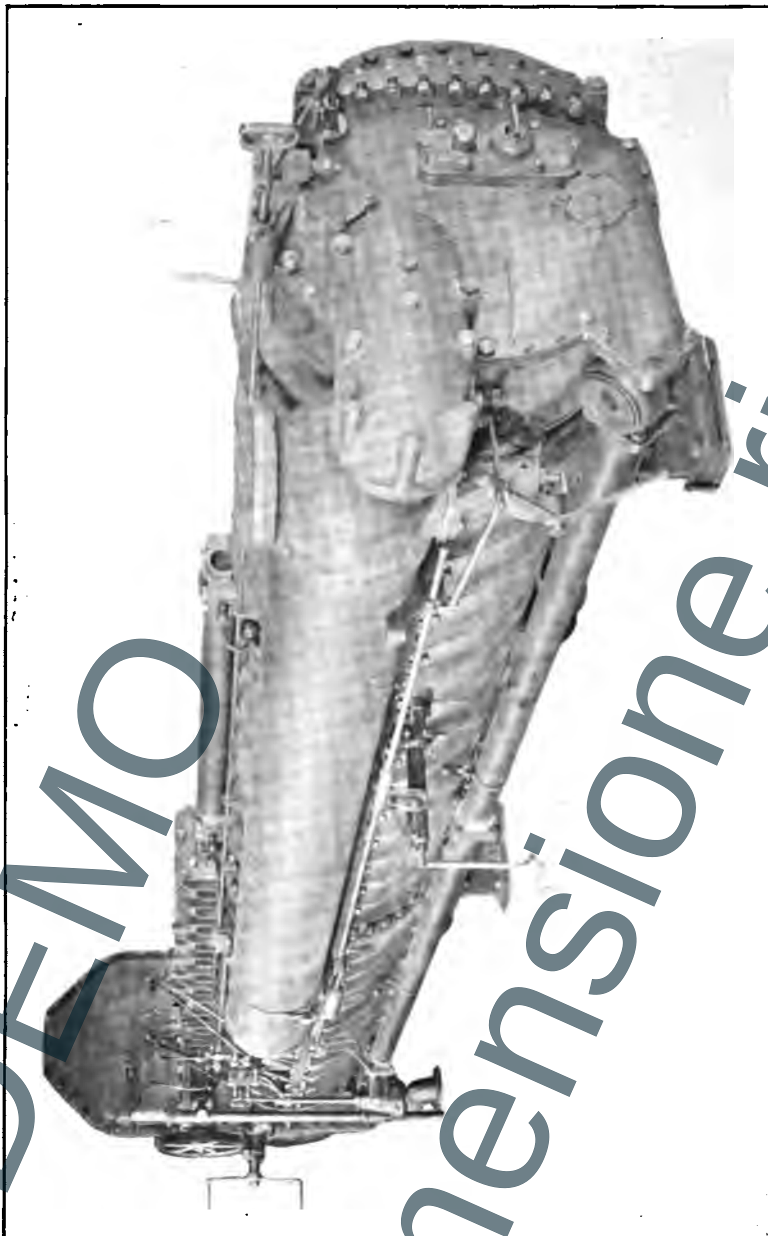
In the summer of 1918, it became apparent that the Bliss Co. would never be able to meet its promised deliveries of 300 torpedoes per month. The bureau was then confronted with the very serious problem of providing torpedoes for the rapidly increasing number of new ships, and to replace the predicted expenditure of torpedoes in the zone of naval operations. The deliveries of the Bliss Co. reached 153 a month.

These low deliveries brought to the attention of the bureau two or three very important facts in considering plans concerning some future time, when it might be necessary to rapidly increase production of torpedoes. Too much emphasis can not be placed on the necessity of having available plants capable of producing air flask forgings. To produce an acceptable forging is a very difficult task, and requires considerable actual experience on the part of any company, experience which can only be gained through actual manufacture. Another is the problem of having available numerous sources of supply for the various parts which make up a torpedo. This work also requires very considerable experience, and can not be successfully undertaken at once, but must be developed in peace times through actual manufacture of these parts.

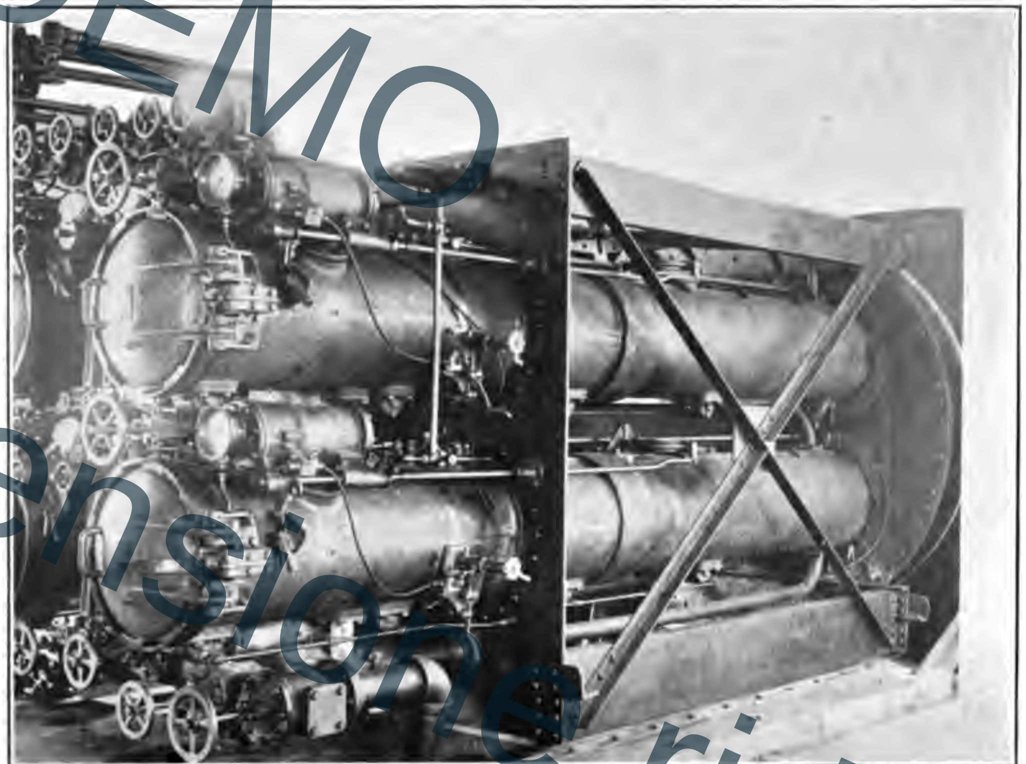
It has long been one of the cherished ambitions of officers who have been vitally interested in the torpedo program of the Navy to see a torpedo assembly plant erected. The idea of a torpedo assembly plant has as its foundation the complexity of the present torpedo. It has been amply demonstrated on numerous occasions that the manufacture of parts for torpedoes is an art and can not be taken up and satisfactorily done without training, which necessarily should be done in peace times. Therefore, if an ideal is to be met, whereby a peace organization can suddenly be shifted to a war organization, with its subsequent increase in demand for the number of torpedoes produced, it has long appeared that the only practical way to accomplish this was by "farming out" the various parts and units of torpedoes to reliable manufacturers in peace times, so that they could become acquainted with the standard of work necessary satisfactorily to produce these parts, and so that, in the event of an emergency, all these various plants where different parts are made could be immediately speeded up and, in turn, a huge assembly plant could be rapidly transformed from a peace-time basis to a war footing, where torpedo output could be very quickly increased.

In the summer of 1918, the torpedo situation, because of low deliveries, became acute, and the bureau was confronted with the problem of finding a new source of supply for torpedoes, which were presently going to be needed. It was then that the opportunity presented itself to bring into existence such a great assembly plant, with all the advantages which make such a plant a valuable asset to the Navy.

The situation was presented to the Secretary of the Navy in August, 1918, and he approved the project. There followed, immediately after this, a search for a suitable location for this plant, and a site at Alexandria, Va., on the Potomac River, was finally agreed upon. Steps were immediately taken to acquire the property and to prepare the plans for this plant. Alexandria affords a very favorable location for such a plant, as it is very near the fleet base at the



21-INCH TORPEDO TUBE, SUBMERGED TYPE, FOR USE ON BATTLESHIPS.



BOW NEST OF TORPEDO TUBES FOR SUBMARINE MOUNTED FOR TEST.

168–2

mouth of the Potomac River, and also will have a standard proving range in Chesapeake Bay for torpedoes assembled there. This range is to be equipped with all the latest devices for recording the performance of torpedoes in the water and is to be the longest range that the Navy has—20,000 yards.

Capt. W. S. Miller, U. S. Navy, was placed in charge of the Alexandria torpedo station project, and the plant, conceived as a war measure, but of undoubted value in peace times, has been constructed since the armistice.

Shortly after the first destroyers arrived in the zone of naval operations it became apparent that there would have to be some sort of torpedo repair and overhaul station ashore at the destroyer base. On November 16, 1917, the Secretary of the Navy ordered the establishment of a torpedo repair station at Queenstown, Ireland. A small force of 2 officers and 23 men, under the command of Lieut. Commander Radford Moses, proceeded to assemble the necessary power plant, testing material, tools, and spare parts and sailed from the United States on December 17, 1917, taking material with them for the establishment of a station capable of caring for 130 torpedoes. A number of these men were civilian torpedo machinists at the torpedo station, Newport, R. I., who volunteered and were enlisted for this particular duty.

On December 30, 1917, work was started in the British dockyard at Haulbowline, Queenstown, Ireland, taking over part of the British torpedo shop. This station proceeded with the overhaul of torpedoes for the destroyers so that it was only necessary for these vessels to make the firing adjustments to their torpedoes. The destroyers were thus relieved of work which would have been very difficult to perform due to the large percentage of time underway, bad weather conditions, and lack of technical knowledge on the part of destroyer torpedo personnel caused by drawing heavily on them for nucleus crews.

On April 1, 1918, a building known as the paravane shed at Haulbowline was turned over by the British for this repair station, and, on May 1, this building (65 by 100 feet) was put in operation, and, by means of the Diesel engine, power plant, and air compressors brought from Newport, R. I., was made entirely self-sustaining.

On July 1, 1918, the force commander decided that this station should be expanded to provide for the overhaul of all torpedoes north of the Mediterranean. The British Admiralty agreed to extend the building to a total length of 325 feet, and it was decided that the United States Government would bear one-half the expense of this permanent construction. The quarters previously erected by the torpedo men were expanded by the addition of portable buildings to provide for quartering 150 men and 17 officers (for instruction). The remaining men necessary to carry out the force commander's plans—namely, overhauling 400 torpedoes per month—were to be quartered at White Point Barracks.

All temporary buildings were erected completely by the torpedo repair station force, assisted by eight men from the U. S. S. *Melville*. The permanent shop extension was only about one-half completed when the armistice was signed.

A class of instruction for officers and men was started and a total of 58 officers and 34 men were instructed in torpedoes. Vessels having torpedoes at the torpedo repair station were required to send one man to witness all tests, and were allowed to send two men for torpedo instruction.

The number of torpedoes overhauled per week was increased as new men were instructed in the work and during the final week before the armistice was signed 45 torpedoes were overhauled. A total of 520 torpedoes were completely overhauled by this station, of which number 82 were received from vessels based on Brest, 11 from vessels based on Plymouth, and 15 from the submarines at Berehaven, and in addition to these 309 were partially overhauled. When the armistice was signed the complement of this station was 13 officers and 185 men.

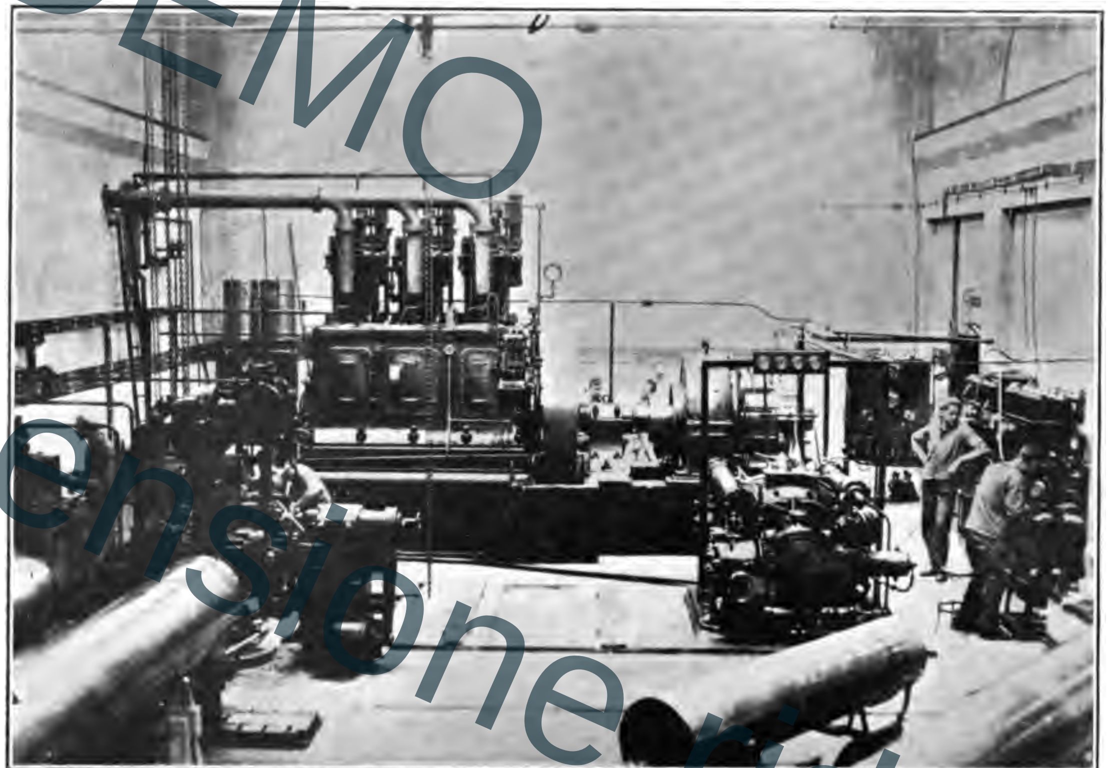
During the progress of this work, many unforeseen conditions were encountered, and the chief special mechanics enlisted for torpedo duty were required to perform structural work and labor of all kinds in addition to their daily torpedo employment. Great credit is due these men, who were civilians but a few months before, for their untiring energy in the establishment of this station and for their excellent behavior and cooperation with the dockyard enlisted men and civilian employees. To the few men of the regular Navy, including the chief gunner's mates, is due the credit for supervising and producing work which was satisfactory to the destroyer flotilla. In the progress of building and demobilizing this station, the only civilian labor employed was on permanent construction.

During the latter part of the summer and the early fall of 1918, there was established at Brest another base, and it was further contemplated to establish other destroyer bases in the Mediterranean. However, Queenstown is to all intents and purposes the only station which had the facilities and the personnel to perform the necessary overhaul work.

Immediately after the signing of the armistice, steps were taken to abandon this station, and it was picked up bodily and put aboard ship and returned to the United States. The special enlisted personnel were also returned to their former duties at the naval torpedo station, Newport.

The largest contracts let by this section of the bureau, aside from torpedoes, were contracts for torpedo launching tubes and torpedo

TORPEDO REPAIR STATION, TESTING SHOP, QUEENSTOWN, IRELAND.



TORPEDO REPAIR STATION, POWER PLANT, QUEENSTOWN, IRELAND.

air compressors. The Crucible Steel Co. of America obtained two contracts for triple, Mk. III, above-water, torpedo launching tubes; the first contract on June 12, 1917, for 100 tubes, and the second contract on October 18, 1917, for 200 more. These large orders for tubes, in connection with other large orders to the Naval Gun Factory and the Navy Yard, Puget Sound, were necessary to meet the destroyer building program.

The Crucible Steel Co., for various reasons, failed to meet the contract rate of delivery, although, after the signing of the armistice, their deliveries were uniform and satisfactory.

In addition to the Crucible Steel Co., the Navy Yard, Puget Sound, Wash., took up the manufacture of torpedo tubes. This yard was awarded orders totaling 554, 21-inch, Mk. III, tubes as follows:

| | |
|---|---|
| June 26, 1917, triple tubes | 26 |
| July 19, 1917, triple tubes | 44 |
| Nov. 20, 1917, triple tubes | 160 |
| Feb. 8, 1918, triple tubes | 160 |
| May 10, 1918, triple tubes | 164 |

When it became apparent that deliveries from other sources would not be adequate, the bureau immediately took up, with the Puget Sound Navy Yard and the Washington Navy Yard, the proposition of increasing their promised tube deliveries to the very utmost. This both yards did, and the Puget Sound yard reached the remarkable production of 45 of these tubes per month. Had it not been for this tremendous increase in production, destroyers would have been commissioned without a part, at least, of their tubes.

Orders were also given to the Naval Gun Factory totaling 252 torpedo tubes, 40 of these for submarines Nos. 109 to 118.

These orders, at the request of the bureau, were expedited, and the Naval Gun Factory more than doubled its production of tubes.

The largest contract for torpedo air compressors was let to the Worthington Pump & Machinery Corp. on November 22, 1917, 300 of these machines being ordered on that date. There was considerable trouble over the award of this contract, as the contractors had had no experience in building torpedo air compressors for the Navy, and because, as the bureau was planning on a very rapid delivery of compressors, no time could be lost or wasted in experimenting to produce a satisfactory compressor. However, contract was finally awarded them, and after some slight initial delays, due to obtaining material and priority, this company commenced to turn out these air compressors very rapidly, and reached the production of 45 machines a month, which met every possible requirement of the building program. The contractors are worthy of very special commendation for the zeal which they manifested in this work and the promptness of delivery which was shown.

already in process of manufacture. Two of these torpedoes will have range in excess of any torpedoes now known to exist, while the third will be capable of a range at a speed greater than any yet realized.

Despite the pressure of work upon production during the war, the bureau considers that greater advances and improvements in torpedoes have been accomplished during this time than for a long period of years.

The personnel of the torpedo section of the bureau had for some years prior to January 1, 1917, consisted of one officer and one clerk. The clerk, Mr. E. L. Bennett, had remained in the service of this section continuously, while officers had come and gone to this station as shore duty. On January 1, 1917, the section was in charge of Commander J. V. Ogan. The demands on this section steadily and rapidly increased, commencing just prior to the declaration of war and continuing throughout the war. In March, 1918, Commander Ogan was relieved to go to sea, and his place was taken by Commander George B. Wright.

The interests of this section cover a very wide and divergent field, both ashore and afloat, and the increasing importance of the torpedo as a reliable weapon is demanding more and more personnel to carry on the work necessary to the maintenance of this material, both ashore and afloat; to formulate the policy regarding the handling, use, issue, and overhaul of this material; and, finally, to carry on the vast amount of development and experimental work that is absolutely necessary to keep the ships equipped with the latest and most reliable type of torpedo.

One of the most serious difficulties encountered during the expansion of this section into a war basis was the lack of highly trained personnel, both ashore and afloat. The complexity of the torpedo, its care, its tests, and its running are of such a nature that they can only be successfully accomplished by men who have had long practical experience with torpedoes. This lack of men was seriously aggravated by the continual assignment of the few on shore to sea duty without relief.

# CHAPTER XII.

## TURRETS.

Everyone is familiar with the exterior of the heavy gun turrets of our battleships. They form probably the most conspicuous part of the ship itself when viewed from any angle, and rightly, for these turret guns are the fighting part of the ship.

Only those who have been inside a battleship turret can appreciate the enormous mass of machinery that is assembled within the barbette, or armored tube, which surrounds the turret. Ton after ton of machinery is crowded within the confines of this small space to operate the guns in action. The guns themselves are so mounted in the turret that only a movement in elevation is permitted; that is, the muzzles of the guns can be raised or lowered, but can not be moved right or left independently. Movement in train is accomplished by moving the entire turret around until it points in the proper direction.

Our present turret design is the result of years of growth and development, by which we have learned the many little things that made improvements necessary. From long experience we have drawn the principles of design and construction which underlie the construction of the turrets for 14-inch and 16-inch guns on our latest ships.

It is quite natural, therefore that turret design and construction did not undergo any revolutionary change during the war. There was, however, a constant, gradual change and improvement, for, by observing the details of the construction and operation of turrets of ships of foreign navies, a thing we had never before been able to do, we learned many practical points and kinks of operation that resulted in much gain.

The fundamental principles of turret design in all navies are very much the same. Foreign navies, like ourselves, have gradually developed the principles of mounting guns in turrets, and, as these improvements have kept pace with progress in the art of shipbuilding, there is little to choose along the broad general lines of design among the turrets of ships of the various countries.

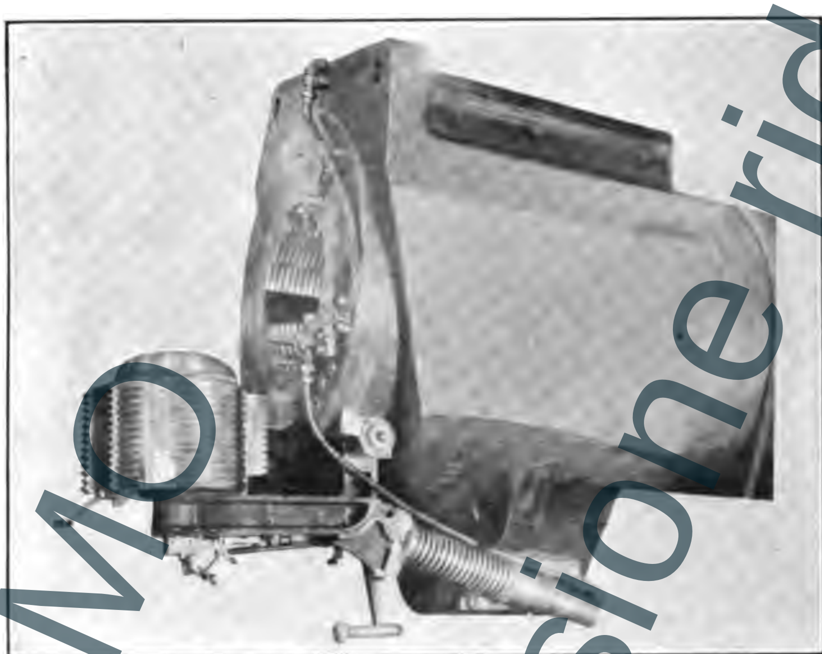
Turret construction and the mounting of big guns aboard ship is a constant struggle between the guns and their turrets and the means of installing them on board ship. The gunmaker can build an 18, 20, or even 24 inch gun, but it is useless to construct such a gun unless the shipbuilder can build a vessel large enough and strong enough to permit mounting it and stand the shock of fire.

Since our earliest battleships, the Navy Department has placed the ship's heaviest guns in turrets. Thus, in the course of the Navy's development, there are the old low-powered 13-inch guns on the *Indiana* and *Massachusetts*, mounted in pairs in turrets. Then came the 12-inch 35-caliber guns of the *Iowa*. The 8-inch guns were placed in turrets of their own, two guns to a turret. Next, in the effort to utilize the same barbette, the 8-inch turret was superimposed on the 12-inch and there resulted the double-deck turrets of the *Georgia* class, with two 12-inch guns in the lower turret and two 8-inch guns in the upper. The *Connecticut* type, the last of the predreadnaughts, reverted to the single-deck turret and carried a battery of four 12-inch guns in two turrets and eight 8-inch guns in four turrets.

With the dreadnaughts the turret design was carried on, except that the 8-inch turrets disappeared and a number of 12-inch turrets were installed, until the *Wyoming* and *Arkansas*, each with twelve 12-inch guns in six turrets, two guns to a turret. With the development of the larger guns, the *New York* and *Texas* mounted 14-inch guns two to a turret. To save weight, a 3-gun turret was developed; and our latest battleships, the *Idaho* type, carry twelve 14-inch guns in four turrets, three guns to a turret, while ships now contemplated will carry twelve 16-inch guns.

Few appreciate the weights of material dealt with in turret mountings for our heavy guns. For instance, the 14-inch 50-caliber gun weighs 95 tons. The slide in which it is held weighs in the neighborhood of 25 tons, and the steel castings, which are bolted to the structure of the turret to support the gun and slide, weigh about 10 tons. Three complete guns, with complete operating equipment consisting of powder hoists, rammers, shell hoists, etc., form a single turret in our latest ships, so that the weight of each of the four 14-inch gun turrets, each carrying three guns, is not far from 2,500 tons; of which total, of course, the armor is the greater part.

Some conception of the enormous size of these turrets is necessary to understand the problem facing the Bureau of Ordnance in seeing that this equipment is at all times in perfect condition, ready for operation on instant notice. Successfully to operate a turret, every piece of machinery, *without exception*, must be in perfect adjustment and condition. All parts of the turret are so interlaced, and the machinery is so complicated, that the failure of one part means a serious reduction in the efficiency of operation of a turret,



BREECH MECHANISM OF 14-INCH GUN. OPEN POSITION.

176-1

14-INCH PROJECTILE AT TOP OF SHELL HOIST READY TO SWING OUT ON LOADING PLATFORM.

176-2

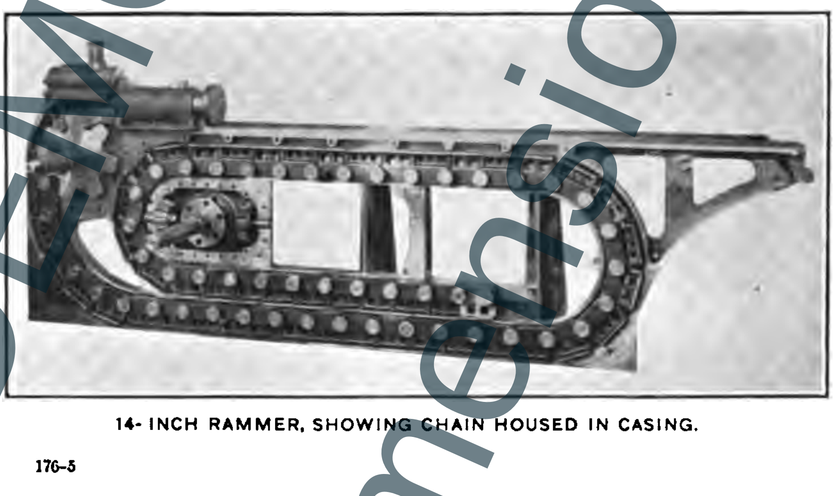
14-INCH PROJECTILE IN CRADLE BEING SWUNG TO LOADING PLATFORM.

176-3

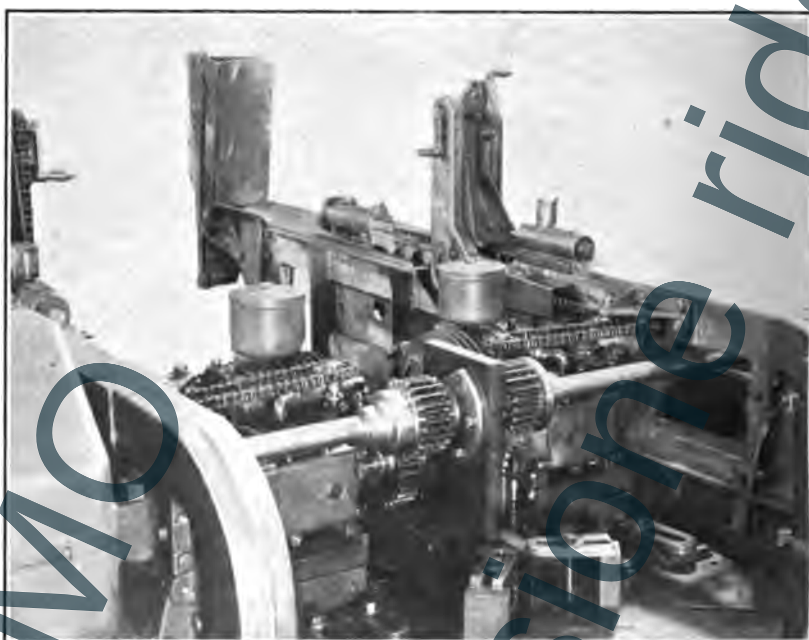
BOTTOM OF 14-INCH SHELL HOIST, SHOWING PROJECTILE, TUBE-HOIST CONTROL MECHANISM, CAPSTANS FOR PARBUCKLING, AND MOTOR CONTROL.

176-4

BATTERY OF RAMMERS FOR A 3-GUN TURRET READY FOR SHOP TEST.



14- INCH RAMMER, SHOWING CHAIN HOUSED IN CASING.

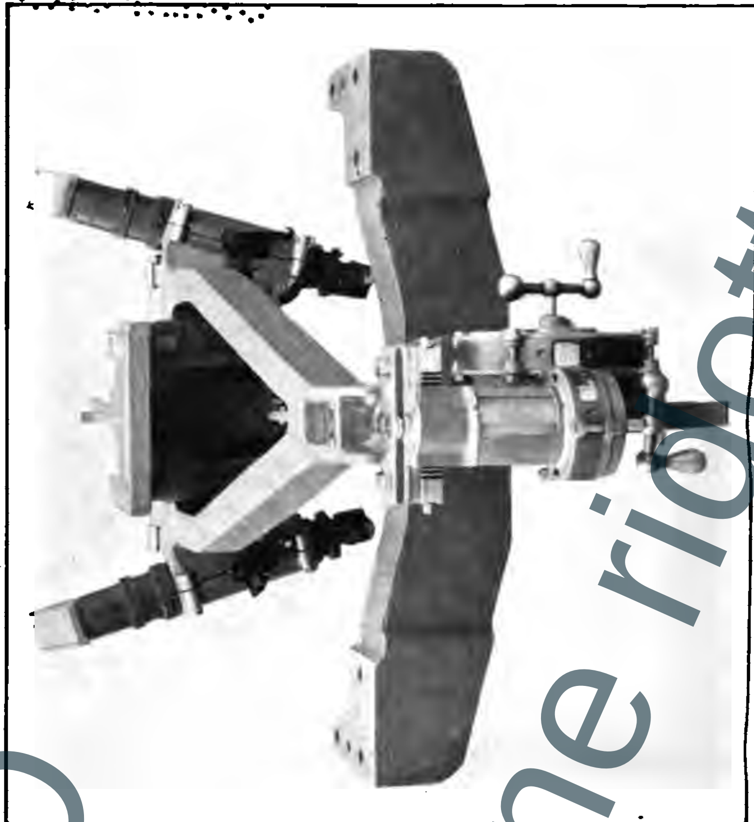


RAMMER EQUIPMENT FOR 14-INCH TURRET VIEWED FROM THE REAR, SHOWING BACK GEARING AND THE FOLDING SPANNING TRAY IN FRONT OF THE RAMMER.

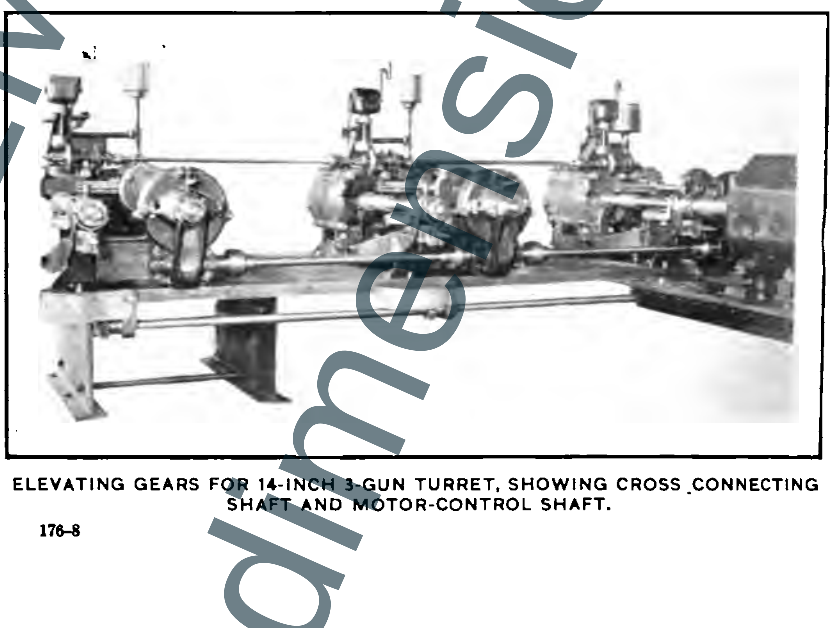
176–6

14-INCH SLIDE ON PLANING MACHINE.

176—7



TURRET SIGHT YOKE WITH TELESCOPES AND RANGE AND DEFLECTION DRUMS.



ELEVATING GEARS FOR 14-INCH 3-GUN TURRET, SHOWING CROSS CONNECTING SHAFT AND MOTOR-CONTROL SHAFT.

if not actually disabling it and placing it out of action. One weak or cracked part, in one of the many machines crowded into the armor-plate walls of the turret, or one loose connection, which results in the failure of a motor to function properly, may cause a 25 per cent diminution of the gun power of the ship, by placing one turret out of action.

Throughout the war, the Bureau of Ordnance maintained all of the turret equipment of our battleships in as nearly perfect condition as it was humanly possible to do. Foreseeing the possibility of hostilities, every step had, at the outbreak of war, been taken to place the turret equipment of our battleships in condition ready for action. Reserves of spare parts had been accumulated and issued to the ships, so that breakages, that will invariably occur, could be easily replaced. Special mechanics from the Naval Gun Factory were sent to the fleet to overhaul and adjust all sights, to insure that they were all in the best possible condition.

During the war, two new ships, the *Mississippi* and *New Mexico*, were commissioned. These ships mount twelve 14-inch 50-caliber guns, and are equal in gun power to any ship in the world.

One of the new developments of the past two years, hastened and, in fact, forced by the outbreak of the war in 1917 was the decision to change the armament of battle cruisers from 14-inch to 16-inch guns. As originally laid down, the battle cruisers were to carry the armament of eight 14-inch 50-caliber guns. As the plans now stand, the battle cruisers will carry armament of eight 16-inch 50-caliber guns. This change will give the United States battle cruisers the heaviest armament of any ships of their class in the world.

The 14-inch 50-caliber gun is 50 by 14 inches—700 inches, or $58\frac{1}{3}$ feet long. In describing a gun, the diameter of the bore and its length in calibers are always given; that is, the number of times the diameter of the bore is contained in its length. The 16-inch 50-caliber gun is 800 inches or $66\frac{2}{3}$ feet long, an increase in length of about 15 per cent. This increase in length, combined with the increase in diameter of the bore, results in an increase in muzzle energy of 50 per cent. The 14-inch gun throws a projectile weighing 1,400 pounds, while the 16-inch gun throws a projectile weighing 2,100 pounds, and, as the muzzle velocity imparted to the projectiles by both guns is 2,800 feet per second, the 16-inch gun is nearly 50 per cent more powerful than the 14-inch gun.

The Navy Department's decision to change the guns of the battle cruisers from 14 to 16 inch, made upon the initiative and after the repeated recommendations of this bureau, was, in effect, a decision to give the battle cruisers a 50 per cent heavier armament. In action, these battle cruisers will throw a weight of metal of 16,800 pounds, or about 8½ short tons per broadside. With their speed of 33 knots, these ships should by far surpass all other similar ships of foreign navies.

Taking lessons from the casualties on board the British and German ships in the battle of Jutland, steps were taken for the better flame-proofing of turrets to prevent casualties, should flarebacks, etc., occur in action.

The entire counter recoil systems of the turrets of our ships, the *Texas*, *Oklahoma*, and *Nevada*, were overhauled, several of our ships received new powder hoists, and several received shell hoists. All alterations and repairs were accomplished without interfering with the ship's most important mission—that of being ready for battle at all times.

Every ship while at sea had its turrets ready for instant use, and every favorable opportunity was taken to overhaul and examine the auxiliary operating equipment and keep it in perfect condition as far as possible.

The officers who handled this work were Commander W. R. Van Auken, June 8, 1916, to April 20, 1917, and Lieut. Commander L. B. Bye, April 21, 1917, to June 7, 1919. This section of the bureau also had cognizance over the railway and tractor batteries, and information, which are described in other chapters.

The real test of the efficiency of the measures taken by the Bureau of Ordnance to keep our battleship turrets in operating condition was encountered when our battleships took their place in the line of battle of the British Grand Fleet. In order to operate there, it was absolutely necessary that every piece of equipment, and particularly the ordnance equipment of the ships, be ready for battle at any moment, for no one knew when or where the German Fleet would essay to sally forth. The fact that the ships did operate successfully is the best assurance of satisfactory work.

## CHAPTER XIII.

## THE UNITED STATES NAVAL RAILWAY BATTERIES.

For two months previous to the signing of the armistice, the United States Navy had in action in France, firing against German troop centers, railroad centers, and points of vantage all along the line, the five heaviest mobile guns on all the western front. The Navy, thus in accordance with methods in previous wars, assisted the Army by operating some of its guns on shore, a duty for which its personnel is by sea training peculiarly fitted. The French and Germans did likewise in the early days of the war, and as time went on and the far-reaching effect of naval bombardment from long-range guns began to be more and more manifest, continually increasing numbers of naval guns were put to this use.

The Germans, for the most part, adopted the plan of mounting their naval guns on fixed shore emplacements, probably because they had a greater number to mount, and they looked for an early victorious close of the war, so that they felt it advisable to get them in action quickly without taking the time necessary to build large railway mounts. They had for some time previous to our entrance into the war dismantled many of their battleships and had placed the guns in action at the front, some on railway mountings, manned by naval personnel. The Allies, as well, had, before the entrance of the United States into the war, begun to reply to the Germans by adopting their own tactics and improving upon them. With infinite care the French built all along their front-line railways numbers of curved sidings, so that on almost instant notice and from almost any point along the front line a bombardment of the Germans could be commenced by railway artillery.

Both the French and British lent their efforts, as far as they could, to the construction of railway artillery and the placing of railway guns in service in France. As was the case with the Germans and the Italians, these guns were in practically all cases manned by naval personnel.[1]

When the United States entered the war against Germany in 1917, the Germans had the better of the long-range artillery argument. Their railway guns outranged those of the British and French.

[1] Extract from Landing Guns on the Belgian Coast, Chap. VII, Vol. I, "The Dover Patrol, 1915–1917," by Admiral Sir Reginald Bacon, K. C. B., K. C. V. O.

"In all big wars it has been the privilege of the Navy to land larger guns than those generally used ashore; so, in this particular, the Dover Patrol was able once again to uphold an old tradition of the Navy."

The Chief of Bureau, convinced of the importance of long-range guns on the western front, on November 12, 1917, recommended to the Chief of Naval Operations the strategic advantages to be gained by placing several of our 14-inch naval guns in action in France.

In making this recommendation, the Chief of Bureau was guided by a close study of the situation abroad which had convinced him that naval guns were needed on shore, to do their part in reducing enemy concentration points, ammunition dumps, and railway lines.

A number of 14-inch 50-caliber guns were available at that time for such uses. These guns were reserve guns for the ships of the Navy in commission and under construction. The probability of their need at sea was slight. On the other hand, their value ashore could be great. The guns were nearly 60 feet long, weighed 90 tons apiece, and fired a projectile containing 88 pounds of high explosive, with a total weight of 1,400 pounds, at a muzzle velocity of 2,800 feet per second, reaching a maximum range, at 43 degrees of elevation, of over 25 miles.

The proposal to place a number of guns on railway mountings, for use with the American Army in France, was approved by the Chief of Naval Operations on November 26, 1917, and, after considering preliminary designs and the best method of using the guns, on December 26, the day after Christmas, the naval gun factory was instructed by the Bureau of Ordnance to work out the details of a plan for mounting the 14-inch 50-caliber naval rifles on railway cars. Work was continued night and day at the Naval Gun Factory, so that on January 25, 1918, complete plans and specifications for the material of the expedition were ready for submission to the bidders.

The battleship turret mount designers, together with men with experience in bridge and locomotive work, called into action to develop the plans, succeeded in less than 30 days in turning out the complete plans for the equipment.

The work of design was done at the Naval Gun Factory by the force under Commander Harvey Delano, whose right-hand man in all this work was Mr. George A. Chadwick. The work of this designer was remarkable and it is primarily due to his excellent judgment that the batteries as assembled carried out their mission thoroughly on the firing lines in France. Capt. A. L. Willard, in charge of the factory, kept up the enthusiasm of the personnel at this task and by his experience and able suggestions guided the project successfully and efficiently.

To Lieut. Commander L. B. Bye, United States Navy, fell the task of coordinating all the efforts to accomplish the manufacture and shipment of all the guns, mounts, carriages, cars, locomotives, and a multitude of other necessary equipment.

14-INCH GUN ON RAILROAD GUN CAR. TYPE USED ON WESTERN FRONT BY U. S. NAVY.

INSIDE OF AMMUNITION CAR, 14-INCH RAILWAY BATTERY.

PLACING 14-INCH 50-CALIBER GUN ON GIRDER FOR TRANSPORTATION TO THE SHOPS.


REAR ADMIRAL C. P. PLUNKETT, U. S. NAVY, AND THE OFFICERS OF THE U. S. NAVAL RAILWAY BATTERIES, WEARING FIELD UNIFORMS SIMILAR TO THAT OF THE ARMY.

The bureau consulted Army authorities, and Maj. Gen. John Headlam, of the British Artillery, who won fame at Mons, also was of great assistance in outlining the project and in drawing up the general requirements which a heavy railway mount must fulfill.

In general, the designs called for an initial construction of five battery units, each battery unit composed as follows:

- 1 gun car, consisting of two large main girders, each 72 feet long, braced and tied together to form a single girder unit with a large center well in which the 14-inch 50-caliber gun with its slide, deck lugs, elevating gear, etc., was mounted. The gun was arranged to fire from the rails at angles of elevation up to 15°. For firing at elevations from 15° to 43° a foundation composed principally of ordinary structural-steel girders and timbers was provided.
- 1 locomotive.
- 2 ammunition cars.
- 1 construction (gondola) car, 1 construction (flat) car with crane, and 1 sand and log (box) car, for carrying foundation material and installing it.
- 1 workshop car.
- 1 fuel car.
- 3 berthing cars and 1 kitchen car for housing operating personnel.
- 1 battery headquarters car for operating offices, housing officers, etc.

In addition, provision was made for a staff train of:

- 1 locomotive.
- 1 staff quarters car.
- 1 traveling machine shop.
- 1 spare parts car.
- 1 staff quarters car.
- 1 staff kitchen and dispensary car.
- 1 staff commissary car.
- 1 staff berthing car.

In all, the initial plans for five units called for:

- 5 gun cars.
- 6 locomotive cars.
- 10 ammunition cars.
- 5 crane cars.
- 11 construction cars.
- 10 fuel and workshop cars.
- 16 berthing cars.
- 6 kitchen cars.
- 1 traveling machine shop.
- 13 headquarters, commissary, dispensary, etc., cars.

## THE DESIGN OF THE GUN CAR.

The heavy weights to be handled and the limitations of French tunnel clearances, track and bridge weights, made design a difficult problem and called for close and careful calculations.

The total weight of the gun car complete is in the neighborhood of 535,000[1] distributed as follows:

| | Pounds. | | Pounds. |
|---|---|---|---|
| Gun, breech mechanism and yoke | 192,500 | Cab | 12,400 |
| Slide, complete | 50,200 | Shell-loading device | 1,290 |
| Elevating gear (screw) | 650 | Girders, including braces (2) | 135,830 |
| Elevating gear (nut) | 2,930 | Trucks (4) | 80,000 |
| Elevating gear details | 1,860 | Truck beams (2) | 33,000 |
| Deck lugs (2) | 10,200 | Compressor, winch, and engine | 1,800 |
| Transom casting | 10,000 | | |

[1] A New York Central locomotive and its tender, class 1,800, weighs 518,240 pounds.

The gun was to be capable of firing at angles of elevation from 0° to approximately 43°. The ensuing reactions due to firing are: At 0°, gun horizontal, trunnion pressure and resulting horizontal reaction, 814,000 pounds. At 43°, trunnion pressure, 966,000 pounds; resulting horizontal and vertical reactions, approximately 700,000 pounds each.

Each of the two longitudinal main girders is 72 feet long, with a maximum depth of approximately 8 feet. The firing load is concentrated, and to properly care for it and insure its distribution through the girder section, the web of the girder, where the deck lugs are applied, is made especially heavy. Special plates were necessary for this section. The two main girders are tied together, and cross-bracketed at each end to form a single girder unit, which weighs 135,830 pounds. A special U-shaped housing is built in at either end of the girder, in which cast-steel H beams, each carrying a center-pin socket, are placed. The center-pin socket of the H beams, respectively, receive the center pins on the two 12-wheel car trucks placed at each end of the girder on which it rests.

The construction of the trucks to carry the gun car is, of course, extremely and exceptionally heavy. Structural steel-girder beams form the frames of the trucks and carry the load to the axles. The axles of the trucks turn in 9-inch by 12-inch boxes, arranged with coil and equalizing springs to insure an even distribution of the load.

The gun is placed in the well, formed between the two girders. To accomplish this, the deck lugs are fastened directly to the web at its heaviest section by means of steel bolts, ground to size to insure a correct fit and an even transmission of the firing stresses. The slide, with the gun and its yoke, is then installed between the lugs, the elevating gear, which consists of a worm in an oscillating bearing operated by hand through a train of gears, being placed beneath and fastened to the girder flanges and crosspieces.

Sufficient clear space is left behind the face of the breech of the gun, so that when the gun fires at angles of elevation not greater than 15° (at 15° elevation the range of the gun is 23,000 yards), all that is necessary is to set the hand brakes on the gun car, after the gun has been properly aimed, and fire. The recoil of the gun is absorbed by the hydraulic brake, and the resultant reaction on the gun car is taken up in moving the entire car backward along the tracks. At 15° the gun car moves backward a distance of about 25 feet. The trunnions of the gun are placed so that the load on the axles of front and rear trucks is equalized on firing.[1]

## THE GUN CAR PIT FOUNDATION.

To enable the gun to fire at angles of elevation greater than 15°, arrangements for a pit and foundation, as mentioned above, have

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[1] On Mar. 23, 1918, two days after the German Army opened its great offensive, the whole world was stirred by a long-range bombardment of Paris. An explosion from a mysterious source occurred on the Quai de Seine at 7.15 a. m. that day, this being followed by similar ones at about 15-minute intervals, until by evening 21 such explosions had occurred. An investigation by the allied air forces developed that this bombardment was being carried on by a gun of novel construction and design located within the German lines in the forest of Gobain of Laon, and operating at a distance of 68.8 miles from Paris.

Many interesting theories were advanced to account for this unexpected achievement. A great deal was published, and there was a great deal of speculation concerning the German gun and mount. It was generally supposed at the time that the gun was mounted on a concrete emplacement, from which it was carefully positioned in elevation and direction to fire on Paris.

Now that the facts concerning the German guns are available, it is possible to make the following comparison of this German gun and those used on the Navy railway mounts:

| | Maximum range. | Weight of projectile. | Muzzle velocity. | Maximum firing angle | Muzzle energy. | Brake load due to firing. |
|---|---|---|---|---|---|---|
| | *Yards.* | *Pounds.* | *Foot-sec.* | ° | *Foot-tons.* | *Pounds.* |
| German gun | 121,000 | 204 | 4,760 | 55 | 41,500 | 127,500 |
| United States naval gun | 45,000 | 1,400 | 2,800 | 43 | 76,087 | 800,000 |

From the above data it will be seen that although the range of the German gun was greater, it fired an extremely light shell compared to that of the American gun, and that in all other respects the comparison is favorable to the American gun. The muzzle energy of the American gun and the forces acting on the trunnions greatly exceeded that of the German gun, and on this account the designing of the American mount was much more difficult. It is now known that the German guns were transported from place to place over existing railways by a specially designed car, and were fired from turntable emplacements which made possible a considerable movement of the guns in train.

It is interesting to note that the girders employed by the Germans for carrying the weight and recoil shock of their long-range gun involve strength lines similar to those worked out independently by the Bureau of Ordnance in its girders for the 14-inch Mark I gun car.

There are other points of similarity in the mounts. The main girders were similar in construction and appearance, and the truck arrangements in the case of the Mark II mount and the German mount are identical. Their design details differ markedly from those of our Army and of the French. In addition to the above, the American mount was exceedingly more mobile and flexible, was designed to fire from the ordinary railroad track within 10 minutes after arrival at the site, an extremely valuable feature in the case of a rapid movement of troops. It should be stated, however, that there is no record that the Germans contemplated firing from the tracks, as was the case in the 14-inch naval mounts, and their design did not include the features necessary for such firing.

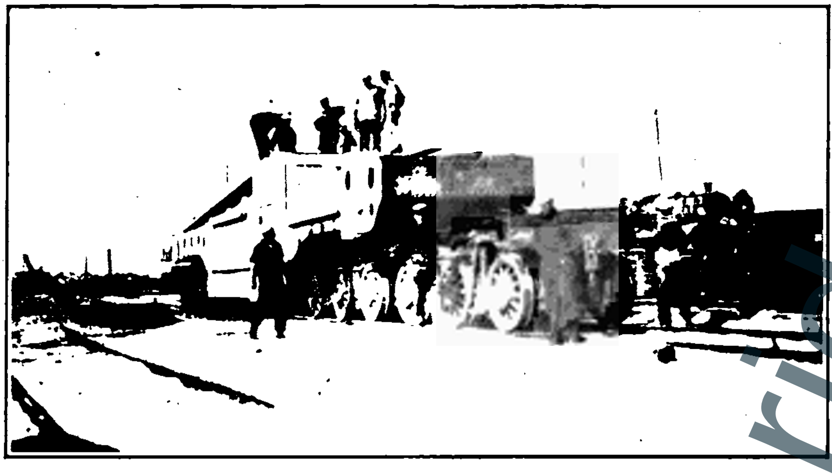
In the case of the turntable used by the Germans in the Forest of Gobain, it required two weeks to erect in the field after the site had been selected. Much preliminary preparation was necessary before the erection of their turntable could be proceeded with. A shop crane was necessary for the handling of the heavy weights of the turntable, this crane requiring the use of considerable extra equipment for its installation. In the case of a turntable that was later proposed by the Bureau of Ordnance for the 14-inch Mark I railway mount, should these mounts be desired for mobile coast defense, the time estimated to erect the turntables in position in the field to fire was 24 hours after the selection of site and arrival of the turntable equipment. Weights were limited to 5 tons, so that they could be readily handled by means of a pillar crane which was part of the train equipment.

been provided. Immediately below the elevating gear, and securely fastened to the girder webs and flanges, is a heavy steel casting called the transom bedplate casting. A similar casting is provided in the foundation. The entire foundation is prepared in advance, it usually taking about 20 hours to get it ready. It is, of course, prepared in advance of the arrival of the gun car at any point at which the gun is to operate. The pit is dug, and by means of the crane car provided, the timber work backing and the structural steel girders are put in place. The foundation bedplate casting is then put into position, and the girders, designed to carry the rails and the weight of the gun car when it is rolled into position over the foundation, are placed.

To prepare the gun for firing from the pit foundation is then a matter of but a few minutes. The car is run over the foundation, until the transom-bedplate casting of the gun car is directly over the bedplate casting of the foundation. One-hundred-ton ball-bearing jacks are then placed under the corners of the H beams at each end of the gun girder, and the entire gun car is lifted from the trucks a distance of about 4 inches. By means of screw jacks, provided in the bedplate casting of the foundation, it is brought up until it engages with the transom-bedplate casting of the gun car and the load of the car rests upon it. The girders, carrying the railroad track, are then moved to either side of the center line of the track, leaving a clear space in which the gun may recoil. Screw jacks are placed under the heels of the girder to prevent side sway and the 100-ton jacks are removed from the forward jacking beams, allowing the entire weight of the gun car to rest on the foundation and rear jacks. The gun is now ready to fire.

Accurate aim, when firing from the rails, is obtained by firing from a curved track, a change in position of the gun car along the track causing a corresponding change in the azimuth of the gun. When firing from the pit, however, this is not possible. Accurate aim of the gun on the foundation is secured through a traversing gear, which permits the entire gun girder to be swung about the forward transom bed-plate pivot through a horizontal angle of 5°, 2½° on each side of the center line of the tracks. As this angle of traverse represents a deflection on either side of the center line of 500 yards at a range of 23,000 yards, corresponding to an elevation of 15°, and correspondingly greater deflections at greater elevations, it is evident that this angle of traverse is ample for all purposes.

The traversing gear is simply a worm shaft turning in a bearing, cast integral with the rear H jacking beam, and operating against the girder. It is operated by ratchet wrenches, and it has worked with entire satisfaction.



14-INCH RAILWAY GIRDER ON TRUCKS READY FOR TRANSPORTATION TO SHOPS.

STATIONARY BOILER PUT IN OPERATION AT ST. NAZAIRE FOR FURNISHING POWER FOR COMPRESSED AIR FOR ASSEMBLING THE 14-INCH RAILWAY BATTERIES.

184-1

BARRACKS ERECTED BY MEN OF THE U. S. NAVAL RAILWAY BATTERIES. 150-TON CRANE IN THE BACKGROUND.

INSIDE OF TEMPORARY BARRACKS FOR CREWS OF U. S. NAVAL RAILWAY BATTERIES.

The loading of the gun is accomplished with an ingenious device consisting of a roller-bearing "trolley-car mounted on an inclined I beam," the lower end of which is placed level with the breech of the gun when the gun is in loading position, level. The 1,400-pound projectile is brought from the ammunition car on a monorail hoist and placed on this trolley. The loading crew then grasp handles at the sides of the trolley and run the length of the car with it. The car is brought to rest against hydraulic buffers at the end of the I beam, while the momentum of the shell is sufficient to carry it the length of the powder chamber and into the bore of the gun, where it is brought to rest by the forcing of the copper rotating band into the rifling of the gun.

The entire gun car is sheathed in one-quarter-inch armor plate. A small combination gas-engine-driven air compressor and winch is placed on the forward truck of the gun car.

## THE LOCOMOTIVE AND AUXILIARY CAR OF THE BATTERY.

The problem of the design of the locomotives and the auxiliary cars of the battery was much simpler than that of the gun car.

The locomotives decided upon as necessary for the work of handling the entire train of cars, including the gun car, are standard, consolidation type locomotives, 1-4-4, equipped for operation on French railways.

As mentioned above, among the points insisted upon was this, that standard United States railway material should be used as far as possible, and only absolutely necessary modifications introduced. Only in this way could material be produced in time, or, in fact, could it be obtained at any time during the war. Manufacturers had no time for extensive changes of design. Consequently, all the cars of the expedition were built fundamentally from American design, but with French operating devices, track gauge, and tunnel heights.

## THE AMMUNITION CARS.

The ammunition cars are standard steel frame box cars of 60,000 pounds capacity. The roof is covered on the outside, and the sides are lined on the inside with armor plate, similar to that which covers the gun car. Doors are placed in the ends of the cars, and a monorail trolley hoist is provided for handling the 1,400-pound shell and the powder tanks, so that ammunition may be delivered directly to the loading device in the gun car. Each car has racks built to hold a total of 25 shell and 25 charges of powder (50 280-pound tanks). The ammunition cars, as well as the other auxiliary cars, are equipped with air brakes.

The construction cars are standard flat and gondola cars, with the exception of the crane car, which mounts a 10-ton pillar crane provided with a counterbalance. The radius of the boom is 21 feet.

The berthing cars are box cars provided with folding berths. These berths are placed in tiers of three each and supported by the side of the car.

The traveling machine shop is of special interest. It is equipped with a gasoline-engine-driven generator, which supplies current to operate individual motor-driven machine tools placed in the car. This car contains a good-sized lathe, drill press, grinder, forge, and work bench, so that ample facilities are provided for the repair of practically any breakage likely to occur to the guns in service.

In the light of the great speed made in the drafting-room work on this project, it would seem not unlikely that there would be a sacrifice in accuracy of detail, thus making changes necessary during the construction of the mounts. Not so with this work. Not a change was made that caused one minute's delay in the work of construction or assembling. The mounts were built exactly as designed and worked successfully.

## THE EXECUTION OF THE PROJECT.

The story of the construction of the 14-inch railway mounts indicates the Nation's patriotic speed in manufacturing, machining, and assembling material during the war. The most satisfactory feature of the entire project was the manner in which the entire equipment fulfilled all the hopes of the persons who had to do with its construction.

The problems to be solved have been outlined in the preceding pages. In addition to the actual work of construction, a large amount of entirely new and important data had to be obtained by special experimental work. A third problem lay in the securing and training of personnel to operate the mounts when completed; a fourth was found in the task of handling the enormous weights and shipping them abroad for reerection in France; and a fifth in the actual work of assembling and reerection in France. The solutions of these problems were carefully thought out and the work systematized so as to allow no "choke points" to form, the result being that the mounts were completed ahead of time and the other phases of the work were in step. The first mount was successfully proved at Sandy Hook on April 30, 1918.

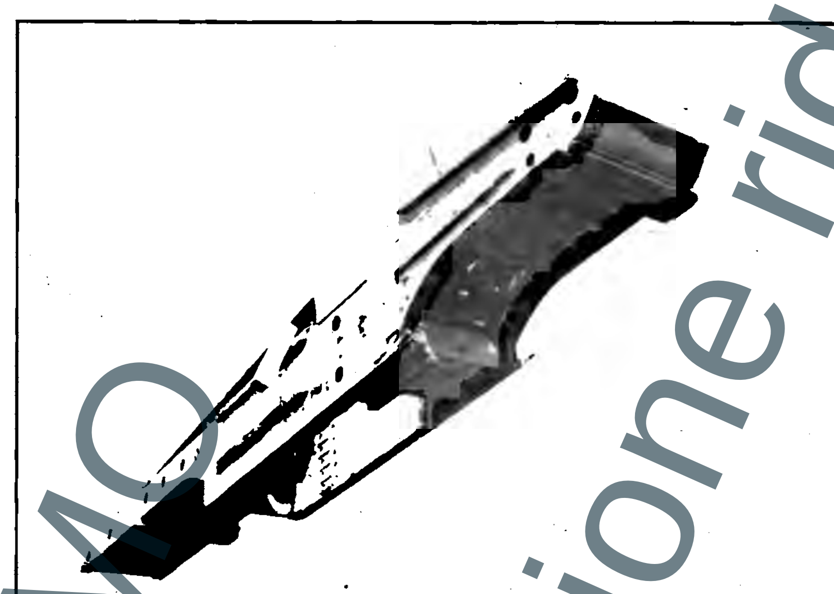
## THE FABRICATION OF THE 14-INCH NAVAL RAILWAY BATTERIES.

Immediately following the completion of the designs on January 25, 1918, proposals were sent out by telegraph to the leading bridge builders and manufacturers of railway equipment throughout the

ASSEMBLING TRUCKS FOR CARS OF THE U. S. NAVAL RAILWAY BATTERIES, ST. NAZAIRE, FRANCE.

TRUCKS FOR 14-INCH RAILWAY BATTERY GUN CARS LINED UP ALONGSIDE OF DOCK AWAITING UNLOADING OF GIRDERS.

The girder is wheeled to the shop by placing it directly upon these trucks.



UNLOADING 14-INCH NAVAL RAILWAY BATTERY GIRDER AT ST. NAZAIRE, FRANCE.

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country with facilities for handling the work, calling for an opening of bids on the morning of February 6, 1918, 10 days later.

From the first, it had been determined that the construction of these mounts would not be allowed to interfere with any work under contract for the United States Army, or with other Navy projects under way. This, of course, greatly curtailed the possible sources of supply for the naval railway battery material, for most of the leading locomotive builders, large machine shops and car construction companies were already working to 100 per cent capacity and had many months' orders on their books. When the bids were opened on the 6th of February, a number of offers to undertake the manufacture of the material were received, but they were not satisfactory, principally because the bidders had not appreciated the full significance of the project, and the dates of delivery set in their estimates were too far distant.

At the first opening of bids, however, representatives of the leading railway-equipment manufacturers of the country were present in person. Over the conference table and behind closed doors, the plans were explained to them. They asked for time to go back to their plants to consult with their directors, and accordingly a second opening of bids was scheduled for February 13.

The cooperation of manufacturers in making the project possible was more than pleasing, and at the second opening of bids a number of favorable proposals were received. Among them was the offer of the Baldwin Locomotive Works, made after the insistence thereon of its vice president, Mr. S. M. Vauclain, without whom the Navy guns would never have operated in France, to undertake the construction of the gun cars and locomotives, on a promise to deliver them about the 15th of June. Similarly, the Standard Steel Car Co. offered to undertake the entire work of constructing the 72 cars that were called for. By distributing the order among their various plants, they were able to promise delivery in from 100 to 120 days. After consideration of all the bids these two were found to be the most favorable, and the contracts were awarded on the same afternoon. On the same evening, the work was commenced on the preparation of the material.

Every war seems to have its one outstanding achievement in speed. During the Spanish-American War, all records were broken by the U. S. S. *Oregon* in steaming from the Pacific coast to Cuba. In the Boer War a famous gun, "Long Cecil," was built at Kimberley in 23 days. In this war, the first 14-inch railway mount was completed in 72 days following award of the contract—120 days following the commencement of the first preliminary designs.

From the moment that the bids were accepted and the contracts awarded the fabrication of material moved rapidly forward. Of course, a delivery schedule was laid down. The most optimistic man at the Baldwin Locomotive Works, Mr. Vauclain, made it out himself, only to have it bettered. The first mount, scheduled for delivery on May 15, 1918, rolled out of the Baldwin locomotive shops complete and ready for firing on April 25, 1918. The last mount was scheduled for June 15 but was finished May 25.

There were no changes in design to delay construction. Plates for the girders were rolled at Pittsburgh and rushed to the American Bridge Co. fabricating plant at Pencoyd in special cars, with Navy men perched on top of them, to see that they got through on time. The first girder unit was received at the Baldwin shops within one month after the order was placed. Meanwhile the work of constructing the trucks for the gun cars at the Baldwin plant, at Philadelphia, was progressing rapidly, and at the Simonds Manufacturing Co. plant, at Fitchburg, rolling of the armor plate was started. As fast as armor plate was completed and tested it was loaded on the Federal Express at Boston and brought through to Philadelphia without change of cars. The gun slide, deck lugs, and elevating gear were machined by the Washington Navy Yard in record time, and where freight cars were not available to carry parts from the yard to Philadelphia auto trucks made the trip. In fact, every conceivable method of transportation was used in seeing that material from contractors reached the Baldwin shops on time. Express cars, baggage cars, freight cars, auto trucks, special messengers, and even suit cases were pressed into service. Notwithstanding bad traffic tie-ups and some of the coldest weather and heaviest snowfalls that have been experienced in the Eastern States in many years, material got there, and got there on time.

While one end of the Baldwin shops was engaged in erecting the gun cars, the other end was erecting the locomotives for the expedition. At the plants of the Standard Steel Car Co., located at various places throughout the country, fabrication of the cars was pushed so that they too were finished in advance of their delivery schedule. In spite of a severe fire and wind storm, which destroyed a considerable portion of one of their large western plants, the contract was completed and the cars delivered by June 1. The start of a complete train load of material from the Hammond, Ind., plant of the Standard Steel Car Co., destined for overseas' shipment as part of the expedition, made an interesting picture.

## THE SHIPMENT OF THE RAILWAY MOUNTS.

The original intention of the Bureau of Ordnance was that these mounts should be used in defense of the channel ports of France, operating with the British Army. But conditions as they existed

14-INCH NAVAL RAILWAY BATTERY FIRING FROM FRENCH BATTLE FRONT, OCTOBER, 1918.

EX-GERMAN BOMB PROOFS OCCUPIED BY NAVAL RAILWAY BATTERY NO. 1, NEAR SOISSONS, OCTOBER, 1918.

RAILWAY CROSSING IN LAON, TAKEN FROM AN AEROPLANE.

1,400-POUND PROJECTILES USED WITH 14-INCH NAVAL RAILWAY BATTERIES.

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in December, 1917, and in April, 1918, were quite different, and it was impossible at the latter time for the British to name a port of debarkation to which the material could have been started as early as April 15, for enormous quantities of material had accumulated at the Philadelphia Navy Yard, the designated shipping point for the batteries. By May 15, with the completion of the project actually in sight, and but two weeks distant, the batteries were offered to Gen. Pershing for use with the American Army in France, and with the French Army. Gen. Pershing's acceptance was immediate; a cablegram was received asking for shipment of the material as soon as possible, and naming St. Nazaire, France, as the port of debarkation. Preparations to ship the material there were immediately effected.

The shipment was not accomplished without difficulties. The first ship assigned for the work of transportation was badly battered by storms on her western trip and forced into dry dock for repairs. The second ship assigned was the *Texel*, which was one of the first ships sunk by the German submarine *U-151* operating off our coast. Finally, however, the steamship *Newport News*, deeply loaded with material, sailed from Philadelphia on June 29, and other ships followed shortly thereafter.

## THE ERECTION OF THE 14-INCH RAILWAY MOUNTS IN FRANCE.

The personnel for the naval railway batteries was ordered abroad as soon as the port of debarkation was fixed, sailed immediately on a troop transport, and arrived at St. Nazaire on June 9, 1918.

For the work of assembly in France, the bureau selected Lieut. Commander D. C. Buell, R. F., an officer of railroad experience, who had watched, as an inspector, the progress of the work at Baldwin's. This officer accomplished his work abroad in record time, despite the fact that all blue prints were lost en route.

St. Nazaire had two great advantages for the erection of these batteries, viz, a 150-ton crane at one of the docks, and French locomotive shops only a quarter of a mile away, equipped with two 125-ton cranes. Outside of the locomotive shops there were a number of tracks available for the erection of the cars of the expedition, and for the finishing touches on the gun cars, after the heavy lifts had been accomplished in the locomotive shops. Two or three miles away were located the Montoir storehouses, in which space was available for the storage of tools, materials, etc., for the batteries. The Nineteenth United States Engineers were located at St. Nazaire, erecting locomotives for the American Expeditionary Forces.

During the first week following their arrival, the men of the battery were busy erecting barracks for their use, a site for which was obtained close to the erecting tracks. The barracks were made entirely by the bluejackets from scrap lumber from locomotive packing cases. The tracks on which erection was to take place were then rebuilt. A stationary boiler was borrowed, a leaky air pipe line overhauled and compressed air for car erection made available.

After this work there was no Navy work to do, pending the arrival of the first shipload of material. But the men turned to with a vim that surprised everyone. Groups of mechanics were sent to the roundhouse to assist the force there, others went to help the Nineteenth Engineers; still others went to work repairing the tracks in the yards, while switching crews were organized to clear up a congestion of work which had piled up and was delaying erection. The willing cooperation of the Navy men and the spirit of "Do what you can to lick the Kaiser" made them friends everywhere. It was more as a reward for the help they had given than anything else that the Nineteenth Engineers cheerfully consented to loan one of their 35-ton steam locomotive cranes for use during the erection of the Navy material. Only four of these cranes were available at St. Nazaire, and all were in use. Without a crane, rapid erection work would not have been possible.

The *Newport News* arrived at St. Nazaire on July 8. As the material was brought from the hold of the vessel, it was taken to the erection tracks or storehouse and carefully placed in spaces previously laid out for it. A discouraging feature was that, in the first shipload of material, there were practically no complete units on which work might be started, and experience had shown that it was suicidal to attempt work on units for which all material had not arrived. The material had piled up at Philadelphia Navy Yard until it was impossible to separate and ship units, and there was nothing to do but wait for the arrival of the second ship. The second and third shiploads of material both arrived on July 21, and erection work was on in earnest.

One feature is worthy of special mention. The blue prints showing the assembly of all the cars of the expedition were sent by special mail from the United States so that they would arrive at St. Nazaire amply in advance of the receipt of material that they might be studied. Whether they were on a ship sunk by submarine, or how they were lost, will probably never be known. The fact is they never arrived. New ones were ordered by cable from the United States, but by the time they were received the project was within a week of completion. The locomotives were assembled entirely without blue prints.

The heaviest single lift for the crane was the gun girder. This was transported to the shops by placing it directly on the trucks, which had previously been erected, and hauling it on its own wheels. Only the heavy lifts were handled in the shops, as the cranes were in almost constant use by the engineers. As soon as the deck lugs and gun slide had been placed in a girder, the gun was inserted in the slide, and the gun car was taken to the outside erecting tracks for completion.

The handling of the heavy 14-inch gun presented a problem. It was far too heavy for the light French flat cars, and as there was no heavy wrecking crane available, a breakdown could not be risked. The difficulty was overcome by using the gun girder as a car on which to transport the gun, the gun being laid between the side girders.

The car erection went ahead steadily on the outside tracks. Material had been placed so that a progressive movement of the cars was possible. The trucks were first assembled, and the frames were then placed on them. The sides and roof of the cars then followed, and last of all the interior work. The task of erecting the gun cars was not nearly as difficult as the erection of the seventy-odd cars for the expedition. On no car were there less than 500 rivets to be driven, and on one car there were over 1,200. In this connection there was a handicap similar to the loss of the blue prints. Through some mishap the packages marked "rivets," on being opened, were found to contain stove bolts, and it was necessary to "borrow" rivets from all over France. As the only rivets available were metric-sized rivets, the cars were put together with them. On some of the sizes for which no metric-sized rivets were available it was necessary to draw large rivets down to the proper size by hand. In spite of these difficulties, however, the erection of the cars was not delayed.

All of the work was done under high pressure. There were insistent calls from the front, day after day, for the guns. They were needed, and needed at once. The response of the men to the call is worthy of the highest praise. The working hours were from 7.30 a. m. to noon and from 1 p. m. to 5.15 p. m., but when 5.15 p. m. came around the men would refuse to quit. In the long summer evenings in France it was possible to see up until almost 10 o'clock, and the men insisted on sticking to their jobs, working steadily until it was too dark to see. It is principally to the whole-hearted willing cooperation of the men that the fine record in the assembly of the batteries was made.

The first gun girder was unloaded from the ship and put in the shop on July 30. On August 11 the completed gun car and the first train was ready to leave for the front in response to orders received from the French High Command. With it there was a complete train of cars. The orders to leave were countermanded before the train started, however, and it was not until the 17th that the first train moved off. It was followed by train No. 2 on the 18th. The last gun car and its train left for the front on September 13; the staff train was completed and moved on the 14th, on which day the barracks at St. Nazaire were evacuated and the storage house entirely cleaned out and turned over to the Engineers. The entire group of naval railway batteries were ready for action on the Western Front two days later.

RECAPITULATION.

| | |
|---|---|
| Designs started | Dec. 26, 1917. |
| Designs completed | Jan. 26, 1918. |
| Contracts let | Feb. 13, 1918. |
| First mount completed | Apr. 25, 1918. |
| First mount proved | Apr. 30, 1918. |
| Fifth mount completed | May 25, 1918. |
| Overseas shipment commenced | June 20, 1918. |
| Arrival first shipment at St. Nazaire | July 9, 1918. |
| Assembly first mount begun | July 26, 1918. |
| Assembly of first train completed | Aug. 11, 1918. |
| First train left St. Nazaire for front | Aug. 17, 1918. |
| First shot fired at front | Sept. 6, 1918. |
| Final erection and assembly of all units completed | Sept. 14, 1918. |

## THE OPERATIONS OF THE NAVAL RAILWAY BATTERIES.

In France the naval railway batteries operated as five separate and independent units, all under the command of Rear Admiral C. P. Plunkett, U. S. N. His principal assistants were Lieut. Commanders G. L. Schuyler and J. R. Bunkley. The batteries were commanded as follows:

No. 1 by Lieut. J. A. Martin, U. S. N.
No. 2 by Lieut. (junior grade) E. D. Duckett, U. S. N.
No. 3 by Lieut. W. G. Smith, U. S. N.
No. 4 by Lieut. J. R. Hayden, R. F.
No. 5 by Lieut. J. L. Rodgers, R. F.

The journeys of these guns took them through practically every famous battlefield of the war. Throughout all these thousands of miles of travel the equipment of the batteries stood up well, and the guns operated continuously from the date the first one arrived at the front until the moment when their fire was ceased by the terms of the armistice.

In general, Batteries Nos. 1 and 2 operated with the French armies, while Batteries Nos. 3, 4, and 5 operated with the American Army at Verdun. During the Meuse-Argonne offensive No. 2 Battery was recalled from the French front and with Nos. 3, 4, and 5 kept the main arteries of communication back of the German lines under constant fire day and night. After completing its mission No. 2 was returned to the French.

Prior to the assignment of targets for these guns on the French front the French proved Battery No. 1 at their proving ground at

Nuisemont. They gave this giant gun a target located about 18 miles distant. Four shots were fired and all landed almost within a stone's throw of each other. The French general was so pleased with the result of the firing that he immediately went to Rear Admiral Plunkett and, after congratulating him, said: "Waste no more ammunition, but go and fire it against the Germans." After the proof firing of Battery No. 1 it was ordered to Soissons to commence a bombardment of the railroad yards at Laon. Here for the next 30 days, despite enemy counterfire and the bombs of aviators falling constantly around the gun car, the bombardment of the railroad yards was kept up.

On October 12, after firing a total of 199 rounds, the battery was ordered to cease firing, as the Germans were evacuating the city.

An examination of the former targets of the battery after the German evacuation by officers of the Naval Railway Battery expedition revealed the full extent of the damage done by the shells from this big naval gun. The craters made by the shells were readily recognized from their great and uniform size, and everywhere was seen striking evidence of their destructive power. A large storehouse was seen reduced to utter ruins by the impact of just two of these enormous projectiles, and another case was seen where a large crater had been dug in the railroad switch yards, tying up traffic and demolishing near-by freight cars. The armistice found this gun at Champenoux ready to commence firing upon the enemy.

To Naval Railway Battery No. 2, commanded by Lieut. (junior grade) E. D. Duckett, United States Navy, goes the proud distinction of having fired the first American shell from an American gun manned by American gunners at the Germans on the western front in the World War.[1] On September 6 from a point in the forest of Compiegne Battery No. 2 fired a shot at Tergnier, an important German railroad center, which was being hard pressed by the Allies. After the first shot the Germans began to evacuate the city, and no more shots were fired.

[1] "Our entry into the war found us with few of the auxiliaries necessary for its conduct in the modern sense. The task of the Ordnance Department in supplying artillery was especially difficult. In order to meet our requirements as rapidly as possible, we accepted the offer of the French Government to supply us with the artillery equipment of 75's, 155-mm. howitzers and 155 G. P. F. guns from their own factories for 30 divisions. The wisdom of this course was fully demonstrated by the fact that, although we soon began the manufacture of these classes of guns at home, there were no guns of American manufacture of the calibers mentioned on our front at the date of the armistice. The only guns of these types produced at home which reached France before the cessation of hostilities were one hundred and nine 75-mm. guns. In addition twenty-four 8-inch howitzers from the United States reached our front and were in use when the armistice was signed. Eight 14-inch naval guns of American manufacture were set up on railroad mounts, and most of these were successfully employed on the Meuse-Argonne front under the efficient direction of Admiral Plunkett, of the Navy."—Gen. Pershing's special report to the Secretary of War, December, 1919.

From this position the gun went to Fontenoy-Ambleny and began the shelling of an enormous ammunition dump located by the Germans in Besny-et-Loisy. Thirty-two rounds sufficed to wipe out this ammunition dump. From this point the gun left for Flavy-le-Martel and commenced firing on Mortiers, another important railroad center. Thirty-five rounds were placed in this town, and on October 16 the Germans withdrew. After the withdrawal of the Germans from Mortiers the American Expeditionary Forces sent an urgent request for gun No. 2 and assigned it a position at Charny, near Verdun. The gun was rushed to this point and installed, and, on the day of its arrival, commenced a bombardment of the town and railroad center of Montmedy. Cessation of firing, due to the signing of the armistice, found this gun at Luneville ready to begin operations against Metz.

Batteries Nos. 3, 4, and 5 left St. Nazaire on the 12th, 13th, and 14th of September, respectively, and after a considerable stay at the American Reserve Artillery Base, were given orders to depart for positions near Verdun, from which they were to open fire on the German main line of communications, running from Metz to Sedan.

A glance at the map will show the importance of this target. At that time the battle front around Verdun ran in almost a straight line due northwest. A railroad connecting the cities of Metz and Sedan also ran in almost a straight line, paralleling the front and rendering it very easy for the Germans to shift troops from one point to another all along the lines between these two cities. The Germans had held this battle line for so long that they had brought this railroad to a high state of efficiency. The only alternative line for the transportation of troops from Metz to Sedan was a small and poorly built railroad running almost due north from Metz to Luxemburg City and from Luxemburg City almost due west to Sedan. These railroads formed a right-angled triangle.[1] Should the Americans be successful in cutting the straight line of communication from Metz to Sedan, it would force the enemy to transport troops by the 50 per cent longer route through Luxemburg and over the poorly improved tracks, etc., of the longer railroad. From this it may be readily appreciated why a captured German document referred to the Sedan-Metz railroad line as "the most important artery of the army of the west."

The city of Longuyon was a detraining point on this Metz-Sedan line, containing a main railroad yard with 15 long sidings and

[1] One of the most prominent of the enemy commanders, Ludendorff, writing of the trench warfare on the western front states his point of view that large numbers of heavy flat trajectory guns such as these Navy 14-inch 50-caliber guns are essential, "as fire falling well into the back areas had been found very effective, rendering supply and relief to the front lines more difficult, and during actual operations hindering the distribution of orders and the employment of reserves."

FIELD NEAR SOISSONS, SHOWING PART OF 12-KILOMETER FIELD TELEPHONE LINE BETWEEN NAVAL RAILWAY BATTERIES NOS. 1 AND 2, WITH CONNECTION TO TENTH FRENCH ARMY ARTILLERY HEADQUARTERS. FRENCH THIRD LINE WIRE AND BATTERY OF 75 MILLIMETERS IN BACKGROUND.

NAVAL RAILWAY BATTERY NO. 1 IN POSITION NEAR SOISSONS, FRANCE.

U. S. NAVAL RAILWAY BATTERY FIRING FROM THIERVILLE UPON LONGUYON.

ONE SHOT FROM GUN NO. 1 OF THE U. S. NAVAL RAILWAY BATTERIES, FIRING AT LAON, FRANCE, STRUCK IN THE CENTER OF THE SWITCH YARD AT THAT CITY.

The force of the explosion was sufficient to utterly demolish a flat car which it struck, dig a large crater in the roadbed, tear up the tracks for a distance of more than 80 feet, raise up the wreck of the demolished car over 5 feet and throw it a distance of more than 15 feet, leaving it on top of an adjacent car that was standing on another rail. This picture shows a portion of the crater left in the roadbed by the explosion of the shell.

FREIGHT CAR THROWN ON TOP OF ADJACENT CAR BY ONE SHOT FROM U. S. NAVAL RAILWAY BATTERY FIRING AT LAON.

numerous storehouses. Montmedy had a large railroad yard, which frequently contained 400 cars, was the headquarters of the Seventh German Army, and had large troop barracks and an aviation field. Conflans was also an important railroad and detraining center, having 20 long sidings in the railroad yard and, in addition, a good-sized roundhouse and repair shop. The destruction of these centers could not fail to have an enormous effect on the facilities with which German operations on the western front could be conducted.

Naval Railway Batteries Nos. 3, 4, and 5 arrived at Verdun early in October, were quickly set in position, and commenced firing. The commencement of bombardment by the naval batteries was the signal for an intense effort on the part of the enemy to put them out of action. Shell bursts occurred regularly within 30 feet of the berthing cars and within short distances of the guns themselves. Numerous times the armor plate covering the gun car and ammunition car alone prevented them from sustaining serious damage. In addition, airplanes were frequently flying overhead and dropping bombs.

Up to the arrival of the naval railway batteries, these important troop and railroad centers on the Metz-Sedan line held by the Germans had been immune from artillery fire, for they were several thousand yards beyond the range of the biggest of the allied guns. The arrival of the naval railway batteries in France was one big stroke in the stemming of the German tide, and contributed largely to the consternation created in the German forces by the vigorous tactics of the Americans.

Despite all the fury of the German counterattack, a constant bombardment of targets of Longuyon and Montmedy was maintained by the naval railway batteries. Battery No. 3 selected as its particular target the Longuyon aviation hangars and field; Battery No. 4, the railroad tunnel at Montmedy and the Montmedy yards; and Battery No. 5, the railroad yards at South Longuyon. On November 3, Battery No. 3 was moved to Charny and took for its target the freight yards at Montmedy. On November 4, an airplane observer reported the entire lower Montmedy freight yards on fire. Two days later, it was determined officially and so credited that the shells from Battery No. 3 had accomplished this work.

There was no let-up in the steady fire of the naval batteries at their respective targets until the last moment before the armistice went into effect. Battery No. 4 fired its last shot at 10.57.30 a. m. on the morning of November 11. This permitted the shot to land a few seconds before 11 o'clock.

From reports received later from Allied prisoners and civilians within the territory under fire, it is evident that traffic on the railway running through Longuyon, Montmedy, and Conflans was at all times seriously hampered and for many days was entirely tied up, forcing the Germans to use the roundabout railroad line running north through Luxemburg and then west to Sedan. When the area was examined by officers of the battery, many places were found where the railroad tracks had been completely severed for a distance of from 40 to 70 feet—the diameter of a 14-inch shell crater. It was reported, in addition to the fire in the yards previously mentioned, that a troop train in motion carrying many Germans had been hit and completely demolished.

In the operations at Verdun, little airplane observation was available. The officers of the expedition, however, developed a system of firing by which shots were placed in a spiral around the designated target, so that even without observation of shots the probabilities of a direct hit were very great.

Official recognition of the importance of the work of the railway batteries at Verdun can be found in the report of Gen. Pershing in his description of the last phase of the Meuse-Argonne offensive, which says:

> Our large caliber guns had advanced and were skillfully brought into position to fire upon the important lines at Montmedy, Longuyon, and Conflans. * * * The strategical goal which was our highest hope was gained. We had cut the enemy's main line of communications, and nothing but surrender or an armistice could save his army from complete disaster.

Also, in his letter to Rear Admiral Plunkett, written after the signing of the armistice:

> Permit me to express to you and to the contingent that served the naval guns under you my sincere appreciation of the very efficient manner in which they cooperated with the artillery of the A. E. F.
>
> Your command has performed a distinctly important service, and I found you at all times eager to carry out our plans in a true spirit of cooperation.
>
> I should be very glad to have you express to all concerned my sincere thanks and appreciation for the work accomplished.

Following the signing of the armistice, all the equipment of the naval railway batteries, with the exception of the gun cars, was turned over to the Army for use in demobilization work. The gun cars themselves were disassembled and returned to the United States, where they are now awaiting future service, as coast defense guns or for the defense of some of our island possessions.

## RAILWAY MOUNTS FOR 14-INCH 50-CALIBER GUNS BUILT BY THE BUREAU OF ORDNANCE FOR THE UNITED STATES ARMY.

The first gun car of the naval railway batteries was proved on April 30, 1918. There had been many who had predicted that the test would be a failure, because they did not see how the gun could work properly. Results of the first test were more than convincing and so, on the return trip from the proving ground on April 30, 1918, a verbal request was made by high officials of the Ordnance Department of the Army to have the Navy undertake to construct three additional gun cars, beyond the five under contract for the naval railway batteries, for the Ordnance Department of the United States Army. This was officially confirmed some days later and a formal order placed with the bureau by the Ordnance Department for the construction of three of the 14-inch gun cars.

This order was placed by the bureau with the Baldwin Locomotive Works, who were constructing the gun cars for the naval railway batteries, during the first few days of May, 1918. The mounts built for the Army were exactly the same in every respect as those constructed for the Navy for its own expedition, and the work of inspection and certification was carried on by the Navy's staff of inspectors.

Work was carried forward on the mounts constructed for the Army at the same pace set on the construction of the naval railway battery gun cars, so that the material took shape rapidly. The first of the three gun cars, ordered by the United States Army in May, was delivered early in July, the second a few days later, and the third was completed and placed on the docks ready for foreign shipment by the Army Ordnance Department on the 18th of July, 1918. With the completion of the first three mounts constructed for the United States Army, actually in sight and but a few days distant, early in July the Ordnance Department placed an order for a second set of three mounts, making a total of six constructed for them. These mounts were identical with the first eight built. The order for these was similarly placed with the Baldwin Locomotive Works.

The organizations of the various contractors who manufactured materials for these gun cars had, by the time the eighth mount was completed, become so expert in the fabrication of this heavy material that still another record was set in the manufacture of the ninth, tenth, and eleventh gun cars. Fabrication of the material started late in July; the three mounts were completed and ready for shipment by the 20th of September, 1918. It had been thought that the record of 72 days from the date of first orders for material to final fabrication and placing on the docks of the Philadelphia Navy Yard for shipment abroad could not be bettered, but on this second order for three mounts for the Army that time was cut by nearly 20 days.

In addition to supplying the six gun cars for the Army, the bureau supplied two ammunition cars for each gun car, in all respects identical with the ammunition cars supplied for the naval railway batteries. These cars, as noted before, were large box cars fitted with frames and racks for carrying the shell and powder, and were sheathed with bullet-proof steel in a manner similar to the gun car. The Navy agreed to supply all the necessary ammunition and powder for placing all the gun cars constructed by it for the Army in active service in France. This ammunition was assembled, loaded, boxed, and made ready for shipment at the naval ammunition depot at Fort Mifflin, Pa., and was subject to the orders of the Army authorities. In addition, spare parts for the gun cars necessary for the operation of the gun were furnished.

## LATER DESIGN OF THE NAVAL RAILWAY BATTERIES.

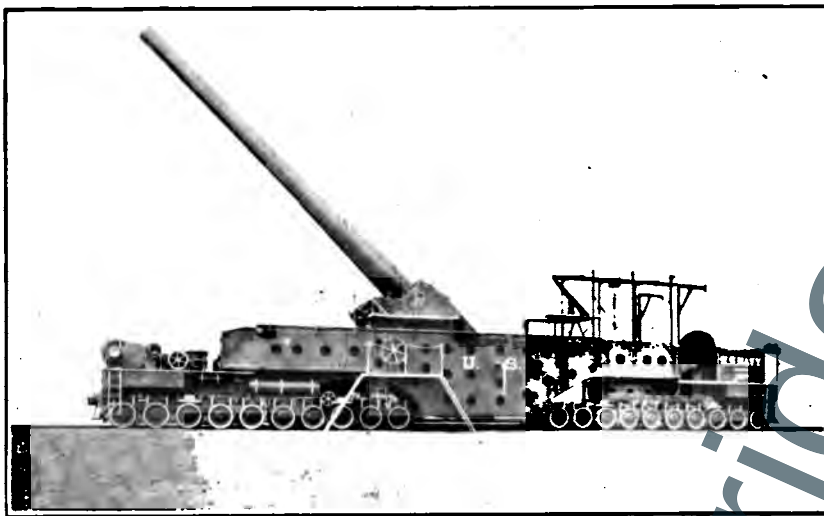
In the design of the railway mounts or gun cars which comprised the fighting units of the naval railway batteries, the vital consideration underlying all principles of design was the factor of time. The naval railway batteries were needed in France, not in 1919 or 1920 but by the summer of 1918, in order that they might do their most effective work, and help, when help was needed, in bombarding the Germans. It was natural, therefore, that when there were two good methods of solving a problem of design that the one offering the least difficulties in the nature of construction, etc., should be followed. For this reason the original Navy gun car designed and constructed by the Bureau of Ordnance made use of as much standard Navy material as possible and followed to the fullest extent standard Navy practice that was sure to work.

The difficulties in connection with taking care of the recoil of the gun have been explained and the method for overcoming them. The factor of time, probably more than anything else, influenced the decision to build a gun car capable of firing at elevations up to 15° directly from the rails, and from a pit foundation at elevations above 15° up to the maximum of 43°. This type of construction permitted the use of a number of standard Navy parts already completed or in process, thus saving the time required in machining them.

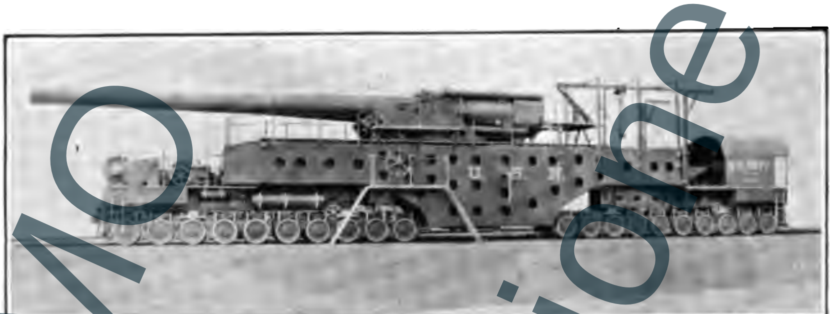
As soon as the naval railway batteries were in successful operation in France and their great value was known, the Bureau of Ordnance took up the question of building a gun car capable of mounting a 14-inch 50-caliber gun and permitting it to fire at all elevations up to a maximum of 43° directly from the rails. This type for some reasons might prove better than the type in operation which necessitated a pit, yet it is not certain, however, that this change will be actually an improvement.

Accordingly, early in October, 1918, Navy designers acting on orders received from the Chief of the Bureau of Ordnance, commenced work on the design of such a gun car.

The problem of railway clearances, that is, of getting the gun and mount through the French tunnels, made the design a difficult, though not impossible, task. In order to come within the limits of




14-INCH RAILWAY MOUNT, MARK II, AT MAXIMUM ELEVATION. NO PIT IS REQUIRED FOR THIS MOUNT




14-INCH RAILWAY MOUNT, MARK II. GUN IN BATTERY.


14-INCH RAILWAY MOUNT, MARK II. GUN HOUSED TO GIVE SUFFICIENT HEADROOM WHEN PASSING THROUGH TUNNELS

these clearances, and yet permit the gun to fire at angles of elevation up to 43° directly from the rails, it was necessary to transport the gun in a lowered position between the gun girder and then raise it by some means into firing position, so that the breech of the gun would not interfere with the rails on firing. It was impossible with this gun merely to dig a pit between the rails because the breech end of the gun has a greater diameter, by over a foot, than the standard track gauge.

A number of proposed means for elevating the gun into firing position had been investigated and considered, among them the idea of raising the gun with its mount up in the gun girder by means of screw jacks, another the idea of firing the gun into position, that is, of utilizing a portion of the recoil energy of the gun to raise the entire gun. All of these, and several others, were found impracticable, and it was finally decided that the only sure way of meeting the conditions imposed was to build the gun and its supporting and recoil mechanism into a single unit, raising this unit from traveling position into firing position by means of hydraulic cylinders.

As soon as the general designs for the gun cars had been worked out and nothing but the preparation of detailed drawings remained, the contract for the construction of an initial order of five of this new type of gun car was awarded to the Baldwin Locomotive Works on a basis of cost-plus-fixed-profit.

At the time this work was under way, the drafting-room forces of the Bureau of Ordnance and the Naval Gun Factory were very much overloaded with work. It was, therefore, arranged that the drafting-room force of the Baldwin Locomotive Works should undertake the preparation of the detailed plans for this new gun car, acting under the direct supervision of designers sent from the Bureau of Ordnance to take charge of the work.

The enthusiasm due to the records made by the Baldwin Locomotive Works in the construction of the original naval railway batteries was still with the drafting-room force of that company, and work on the designs of this new gun car was pushed with a vim. A few experienced Navy designers, in addition to those supervising the work, were sent to Philadelphia from the Naval Gun Factory to work out the purely ordnance features of the design, while the Baldwin Locomotive Works designers worked on the railroad and car features. The combination of work and the results achieved far exceeded all expectations, for with a rapidity not dreamed of the designs took shape. The work was so planned that detailed drawings for material required to be manufactured by outside contractors and special material were finished first. Thus all drawings for plates, which had to be rolled by the plate mills, and for steel castings, patterns for which had to be manufactured before the castings themselves could be made, were ready for issue within a week, and, before any of the minor details had been touched, orders for the larger items of material and those requiring the longest time for manufacture had been placed. Following this, work was continued on the smaller items and material orders placed for these as well.

By the end of October, work was underway and, at various manufacturing plants here and there throughout the country, it was going forward every minute of the 24 hours in the day. It was expected, on November 1, that the first of these gun cars would be ready for proof and shipment abroad by the 1st of January, 1919, and that the other four would follow within a few weeks thereafter, so that by the 1st of March, 1919, a battery of five of these weapons would be in action on the western front.

The signing of the armistice, of course, cut short the urgent necessity for this material. Such progress had been made, however, that it was decided to proceed with the construction of two of these gun mounts, canceling the order for three of the five originally contracted for, and work on these two was slowed up as much as practicable.

The first of these gun cars was completed on July 17, 1919, and a few days later was transported by rail to the Naval Gun Factory, Washington, D. C., thence by barge to the Naval Proving Ground at Dahlgren, Va. At Dahlgren, on the morning of August 5, 1919, in the presence of Army and Navy officials and prominent engineers, the mount was tested. Everything functioned perfectly—not the slightest trouble was experienced in firing. It was demonstrated that the gun could be run to the firing point, traveling over railroads at a speed of as much as 25 miles per hour, and within six minutes after its arrival at firing point be ready to fire its first shot.

The new Navy gun car has a wheel base of about 83 feet, and as the gun overhangs the forward end and the cab the rear end of the car somewhat, the total length is not far from 110 feet. It weighs the enormous total of 610,000 pounds, or 305 tons, and is supported on 40 wheels.

## THE FUTURE USE OF OUR RAILWAY GUNS.

All of the railway guns constructed by the Navy for service in France during the war are now in the United States, and they have been delivered to the War Department.

They form a most valuable gun for coast defense, for they are equal in size to any gun now afloat on any warship in the American Navy (but few in foreign navies have guns larger than 14-inch caliber) and, by reason of their 40° angle of elevation, they outrange the guns of any warship in existence.

The designers of the bureau have worked out a plan whereby simple emplacements can be manufactured for these guns and set up in the field. The guns can then be placed upon them, jacked in place, and become the equal of a gun on a fixed land emplacement. These field foundations on emplacements are so designed that an all-round angle of fire can be obtained, that is, the mount can be traversed by hand through the entire circle of 360°.

If desired, several emplacements or turntables for these guns may be prepared at strategical points and, when it is desired to use the gun at any one of them, a locomotive can be coupled to the gun car and the entire gun and its mount quickly moved to the desired point. One of these railway mounts, therefore, becomes the equal of many fixed guns for coast defense.

The improved type of railway mount, or the "railway gun car Mk. II," which fires at a maximum range directly from the rails, does not, of course, need a turntable arrangement, or any other preparation other than the installation of a curved track. This makes this gun, as well as the original type of naval railway gun, an extremely valuable coast-defense weapon. It is only necessary to provide a curved track to permit the gun to fire in any direction.

Any of these railway mounts can be moved from one coast to the other on very short notice. On almost instant demand, a locomotive can be coupled to them, ammunition cars and all material needed for operation coupled on behind, and the entire outfit can start for the opposite coast within a few hours. They can make the transcontinental trip at a speed of 25 to 30 miles an hour and arrive at their destination within a week's time.

## CHAPTER XIV.

## TRACTOR BATTERIES.

A great need of our Army in France during the year 1918 was for artillery. The cry of our forces in France was always for guns, guns, and still more guns. Although the British and French factories were doing their utmost to supply the American Army in France with ordnance material during the period required for the plants in this country to get into production and quantity manufacture, there was still a dire need for ordnance. In particular, the cry was for heavy and high-powered mobile ordnance, such as a major-caliber field piece with a range of 20,000 yards or so; that is, a field piece that could travel over any country over which the standard artillery tractor could go, and could be transported from place to place without disassembling.

All large field guns in use by the British, French, and Italian armies as well as many smaller and less powerful guns and howitzers were only semimobile—that is, they were so constructed that in order to transport them the entire gun and mount had to be taken apart, the pieces loaded on separate trucks and transported as separate units, making it necessary for them to be reassembled before fire could be recommenced. Several hours of hard work, of intensive preparation and reassembly, were necessary, therefore, before a gun of any size could be made ready to fire after arriving at the firing point. There was no such thing as a really high-powered, large-caliber field piece that could be transported to the front at a moment's notice and would arrive there ready to commence fire on the enemy.

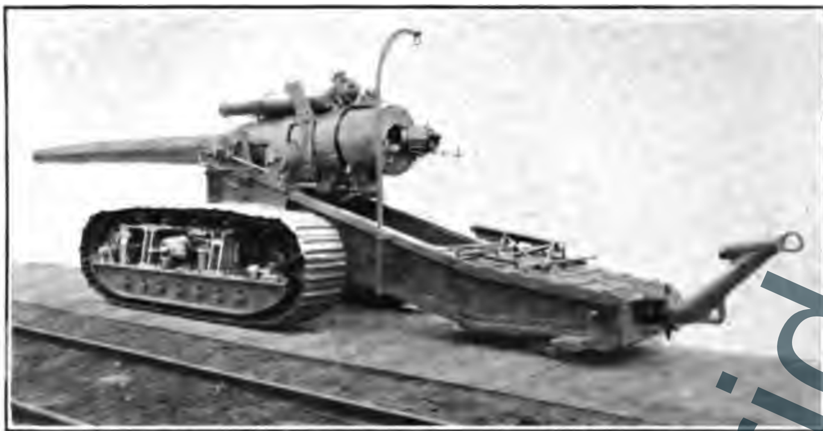
Almost by chance, in the spring of 1918, a number of 7-inch 45-caliber naval guns became available for service. These guns had been removed from battleships of the *Connecticut* class. These battleships, when built, were provided with a secondary battery of 7-inch 45-caliber guns mounted between decks. These 7-inch guns gave excellent service and were a good selection for the work that was expected of them until the war broke out and ships of this class were assigned to convoy service. In this service a light, quick, and hard-hitting gun was needed. Further, the ships were required to be as nearly torpedo proof as they could possibly be made, for no one knew when a torpedo or mine might be encountered. Experiences of torpedoed war vessels clearly demonstrated the danger of having wide gun-port openings near the water line, and ships of the *Connecticut* class were at fault in this respect, in that the mounting of these heavy 7-inch guns between decks left wide openings in the sides of these vessels, so much so that should a heavy list lower one side of the ship an inrush of water sufficient to capsize the ship might be expected. In view of these facts, the department decided to remove the 7-inch guns from between decks on these battleships, permanently sealing the gun ports, and mounting smaller guns one deck higher.

These 7-inch guns were too heavy for installation on armed merchantmen. But no guns in time of stress should be unused. Therefore the chief of bureau, having in mind the need for a really mobile field mount in France and knowing that the 7-inch guns were available for this service, ordered the Naval Gun Factory, early in March, 1918, to prepare designs for mounting and placing in action on the western front a battery of these 7-inch guns.

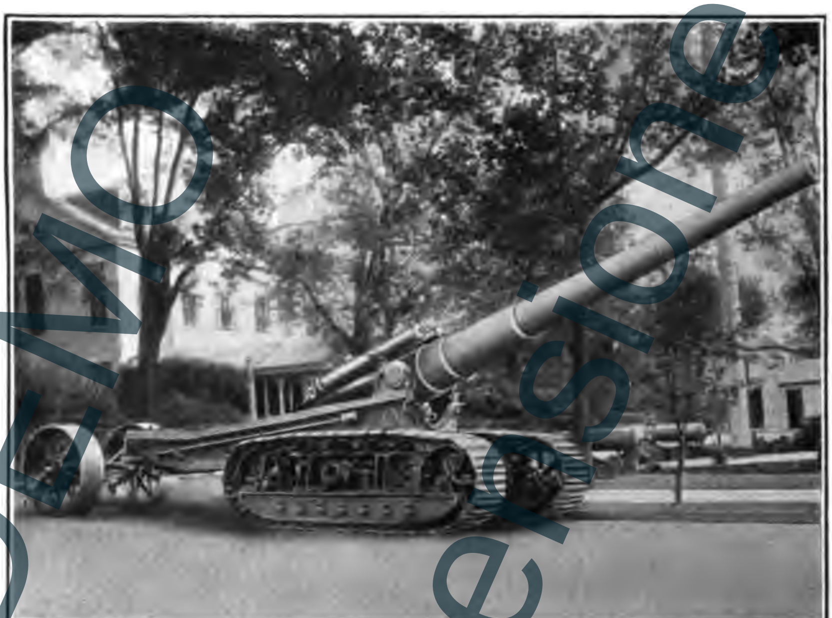
The 7-inch guns removed may be described about as follows: The gun, with breech mechanism, weighs 28,700 pounds, or about 14 tons. It is 45 calibers, 315 inches, or about 26 feet long, and gives a 153-pound shell a muzzle velocity of 2,700 feet per second. At a range of 14,000 yards the shell has a remaining velocity of 1,250 feet per second and can penetrate several feet of concrete or earthworks. The shell carries a bursting charge of 24 pounds of TNT. Its maximum range at an elevation of 40° is in the neighborhood of 24,000 yards.

On board ship the mount for the gun weighed nearly 30,000 pounds, so that the total weight of the gun and mount was not far from 30 tons. When the gun recoiled after firing, the maximum trunnion pressure exerted was about 195,000 pounds. A hydraulic brake took up the recoil through a distance of 21 inches, and the gun was brought back to battery or firing position in the usual way, by means of heavy helical springs contained in spring cylinders attached to the slide in which the gun operated. The mount was designed to allow a maximum elevation of the gun of 15°, which allowed a range of about 14,000 yards.

Early application for a number of these guns was made by the United States Army, and those requested were delivered. The guns, thus turned over, were mounted by the Army on railway cars. Special cars were used for this purpose, built with a drop-frame bed, so that the entire 7-inch gun and its mount, exactly as it was used on board ship, could be placed on it and yet clear the French tunnel roofs, when in transit. These were not put in operation abroad.



7-INCH GUN ON CATERPILLAR MOUNT (WEIGHT, 76,000 POUNDS) ON FIRING POSITION. BREECH OPENED, GUN READY TO LOAD.



7-INCH GUN ON CATERPILLAR MOUNT.

7-INCH TRACTOR MOUNT FROM PEN AND INK SKETCH.

PROOF FIRING OF THE 7-INCH CATERPILLAR MOUNT.

relation of management and employer to labor, and collected, tabulated and filed for reference the general conditions surrounding industrial plants. By means of this organization, the bureau was able to keep in touch with all conditions at its industrial plants, and at private plants doing work for it, and was often able to forecast unrest or, when discovering the same, prevent its growth or spread by careful remedying of conditions or the adjustment of differences between employer and employee.

The bureau's representatives in no way acted as conciliators or mediators, but rather as means of communication by which an impartial review of the situations arising might be laid before the employer and employee, and thus cause to be remedied unfavorable conditions, such as transportation, housing, amusements, living costs, etc., or cause to be removed impressions or conditions tending to cause or increase the spread of labor unrest. *It is a noteworthy fact that at no industrial plant, where Navy ordnance material was being manufactured, did any strike or walkout last more than 48 hours, and in many cases walkouts were prevented, or the men returned to work almost immediately after walkouts, by the bureau's representatives after a thorough investigation of conditions, and mutual understanding was established between the contending parties.*

The general inspector's industrial staff consisted of Lieut. Commander S. C. Mastick, R. F., Lieut. H. G. Dohrman, R. F., Lieut. J. F. Easterbrook, R. F., Lieut. G. H. Johnson, R. F., and Lieut. E. L. Tinker, R. F., operating directly under the general inspector and coordinating with the office of the Assistant Secretary of the Navy; in addition to these, there were other commissioned officers in the field service actively engaged in keeping in touch with industrial conditions.

Ensign B. B. Weiss, afterwards Lieut (j. g.), R. F., was detailed as liaison officer between the office of the Secretary of the Navy, the War Department, and the office of the general inspector of ordnance, and by this means was able to cooperate with the War and Navy Departments in connection with all industrial situations. By such cooperation, it was possible to maintain production of war material by insuring cordial relations and cooperation between employer and employee and, what is more important, furnish an unprejudiced means for communication and cooperation between the departments, organized labor, unorganized labor, and employers of labor.

The labor section was only well under way upon the signing of the armistice, but from the excellent results obtained during its short period of existence, it is believed that in a few more months its influence would have been much more strongly felt. As specific instances of the effectiveness of this organization, there is mentioned the adjustment of difficulties at the works of the Mead-Morrison Manufacturing Co., Boston, Mass., whereby a general walkout was prevented, so that production of gun mounts, so necessary for the manning of the main and auxiliary vessels of the Navy, was not delayed; a general strike at the works of the E. W. Bliss Co., New York City, which lasted but a few hours, was immediately adjusted and the men returned to work so that the production of torpedoes and torpedo material was continued at the full capacity of these works. Labor difficulties at Hagerstown were adjusted, as well as in smaller towns in the surrounding country; the control of labor unrest in the Pittsburgh district, and especially the handling of the Pittsburgh railway labor situation in the fall of 1918 was most important; the maintenance of production in the Chicago district; the adjustment of difficulties at Waterbury and at Danbury, Conn., and the handling of the labor situation at Bridgeport, Conn., were all of far-reaching results. There was much excellent work done by this section's representatives in the New Jersey district, in preventing several threatened walkouts and in clarifying situations which would otherwise have resulted in the slowing up or possible stoppage of production; the adjustment of difficulties at the Defiance Manufacturing Co., Philadelphia, Pa., at the York Manufacturing Co., York, Pa., and other minor threatened labor disturbances and unrest in the immediate vicinity of Philadelphia are worthy of mention as having been accomplished most successfully by this bureau.

Perhaps the action of this section most worthy of mention was the adjustment of labor difficulties incident to the construction of the extension to this bureau's industrial plants for the manufacture of powder at Indian Head. This being a plant situated far from industrial centers and at considerable distance from any city or even village of any size, conditions were most unfavorable for the employment of labor or for maintaining the contentment of labor after employed. Much friction soon developed between the contractors and their employees, and the services of the labor section were often called upon to maintain construction at its required rate of progress. From the experience gained in adjusting difficulties at this place, the Bureau of Ordnance recommended a policy to the Navy Department, as follows:

(1) Eight hours to constitute a day's work.
(2) Time and a half to be paid for all overtime work.
(3) Double time to be paid for Sunday work.
(4) Forty-eight hours to constitute a week's work.
(5) No overtime to be paid to any employee who had not worked more than 40 hours during the week for which overtime was claimed.

The Navy Department approved this policy and promulgated it as the Navy Department's policy, and it was immediately instituted in all of the Bureau of Ordnance industrial plants and at the plants of firms doing work for the bureau. The bureau takes pride in the fact that this policy, determined upon from its experience, became the policy of the War Labor Board, and was promulgated by that board as such at a later date.

The effectiveness of the bureau's policy in keeping informed of all labor conditions and keeping in touch with the mental aspect of labor, was manifested in continued production of ordnance material provided by this bureau at the highest rate of speed.


NAVY ORDNANCE FLAG.

Approved by the Secretary of the Navy October 18, 1918, and authorized to be flown over Bureau of Ordnance industrial plants and stations and over such private industrial plants as are devoting at least 50 per cent of their capacity to Navy Ordnance work.

NA [illegible]

[illegible]

[illegible] quality [illegible]
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UNITED
STATES

# CHAPTER XVII.

## NAVAL ORDNANCE STATIONS.

The Bureau of Ordnance exists as an administrative unit of the Navy Department. Its duties, as has been outlined earlier, are to supply ordnance equipment to the fleet. It might well purchase guns, ammunition, and other materials by contract and ship these direct to the vessels to which assigned, provided only the ordnance materials were as standardized and as common as furniture and chinaware.

But naval ordnance equipment is of a class to itself. Its manufacture can in large degree be carried out by private contractors, but only under rigid specification and inspections. The assembly and test of all material, however, and, in fact, even the manufacture of certain items, must be carried out under more direct control of the bureau than that of inspectors at a private plant. Naval officers and naval crews must use this material aboard ship; the responsibility for its satisfactory action or its failure lies upon the bureau. An accident causing great loss of life, an inefficiency of material leading to the loss of an opportunity to inflict severe damage upon the enemy, may result from failure of even the smallest part of ordnance equipment.

To best insure the quality of the ordnance materials issued to the service, the bureau therefore maintains under its own direction a number of naval ordnance stations ashore, commanded by seagoing naval officers of ordnance experience, and operated under direct orders from the bureau.

To each of these shore stations falls one or more of the duties of manufacture, assembly, overhaul, and test of ordnance equipment. These stations comprise the gun factory, proving grounds, powder factory, torpedo stations, mine depots, armor plant, ammunition depots, and the several commercial plants for the manufacture of ordnance gear taken over and operated by the bureau during the war.

The work of the ammunition depots in assembling and overhauling ammuniton for issue to the naval and armed mercantile fleet has been described in the chapter on ammunition. Similarly, the operation of the several plants taken over has been noted under the chapters descriptive of the material which those plants turned out.

The Naval Gun Factory at Washington, D. C., was early established to supply the naval service with guns. By many expansions this plant has kept abreast of the peace-time needs of the Navy. In war, naturally a vast amount of guns was procured from outside firms, but that these firms were able to perform the work is due largely to the information and cooperation furnished them by the gun factory.

All ordnance material must necessarily be tested, and the only test for a gun, a projectile, or a powder, which is really worth while is actually to fire it. Every gun the Navy uses is first fired to test its strength; a sample of every powder index and of every lot of projectiles is fired to insure proper action. For 30 years the bureau has maintained a testing or proving ground at Indian Head, Md. During the war, an additional proving ground at Dahlgren, Va., was developed in order to obtain the long range required for testing modern, high-powered guns.

Like its guns, the Navy manufactures in large part its own powder. This is done at the Naval Powder Factory, an adjunct of the proving ground at Indian Head.

Perhaps the most complicated and delicate weapon of naval ordnance is the torpedo. The bureau maintains the Naval Torpedo Station, Newport, for the manufacture, test, and overhaul of torpedoes, the Naval Torpedo Station, Keyport, Wash., for the overhaul of torpedoes belonging to vessels on the Pacific coast, and, during the war, inaugurated the torpedo assembly plant at Alexandria, Va., for the production in quantity of torpedoes. The Naval Gun Factory at Washington, D. C., also has recently taken up the manufacture of torpedoes.

Prior to the war, comparatively little was done in mining in the United States Navy, and such ordnance material work as was concerned therewith was carried on by manufacture at the Navy Yard, Norfolk, and by assembly and issue at the several naval ammunition depots. With the enormous advance in mining during the war, however, the bureau, although manufacturing its mines by outside contract, provided a large mine depot at Yorktown, Va., and a smaller one at New London, Conn.

Some time prior to the war Congress had authorized the construction of a naval armor plant and made appropriations therefor. At the beginning of the war, the construction of this plant had been commenced at South Charleston, W. Va. As the war progressed, it became apparent that little armor would be needed but that guns were a constant necessity. Accordingly, provision was made for the manufacture of gun forgings at the armor plant, and in view of this additional character of work, it is now known as the Naval Ordnance Plant, rather than the Armor Plant.

During the war, practically all the ordnance shore stations were actually enlarged both in land and in buildings. Additional and extensive building operations became necessary, and an officer was detailed to act in a liaison capacity between the Bureau of Ordnance and the Bureau of Yards and Docks in regard to public works and ordnance.

The volume of work increased so rapidly that on July 1, 1918, a Buildings and Grounds Section was formed to have cognizance over the layout, development, arrangement, and construction of all buildings and grounds at ammunition and storage depots; manufacturing, assembling, loading, and industrial plants; housing; railroad connections and equipment; roads, wharves, slips, piers, and water, light, sewerage, and communication systems under the cognizance and control of the bureau. Lieut. Commander W. W. Little, R. F., was in charge of the section, which later expanded to a personnel of 12.

Consideration of follow-up and financial questions, in consultation with sections concerned, of all matters relating to plant requirements at naval ordnance stations, ammunition depots, magazines, mine-loading and storage depots, torpedo stations, gun factory, and proving ground, required the examination of all plans and proposals submitted by the Bureau of Yards and Docks in connection with the layout and construction of all buildings, grounds, and public utilities of those stations and of other ordnance industrial plants.

New projects were started as the necessity therefor arose; notably the new proving ground at Dahlgren, Va., the Navy mine depot at Yorktown, Va., torpedo assembly plant at Alexandria, Va., and storage buildings for ordnance material at Bellevue, D. C. The total amount of land taken for all improvements amounted to approximately 14,873 acres, of which about 14,174 acres were for the mine depot at Yorktown, Va., and the proving ground at Indian Head, Md., and Dahlgren, Va. Storage facilities at all depots and stations were increased by approximately 2,000,000 square feet of covered area over prewar conditions.

Detailed notes follow of the operations of the naval ordnance shore stations during the war.

## THE NAVAL GUN FACTORY.

To the Naval Gun Factory belongs the distinction of being the oldest, and at the same time the most important, manufacturing plant under the Bureau of Ordnance. Established early in the last century in Washington, D. C., it has been the main source of supply of guns and their appurtenances to the Naval Service. From the days of the old muzzle-loading smoothbores—the 18, 30, and 60 pounders of the frigates and ships of the line—to the advent of the first rifled Dahlgrens in Civil War times; then on to the present day, with its great floating batteries of 14-inch rifles capable of sinking an enemy at a range of 20,000 yards, the Naval Gun Factory has been fully abreast of every advance in gun construction and has kept our Navy equipped with ordnance unexcelled by any afloat.

At the beginning of the war, the gun factory was supplying the greater part of the guns needed for such vessels as were from time to time added to the regular Navy, and also replacements for the guns worn out in service. The guns were received as rough forged cylinders of various diameters, from which the finished gun, of concentric elements shrunk together, was machined, assembled, and completed. In addition, a great deal of ordnance material of other kinds was fabricated there, such as gun mounts of all kinds, sights and sight equipment, spare parts and accessories for guns and mounts, turret ammunition hoists, cartridge cases and fuses, torpedoes and torpedo tubes.

Special mention should also be made of the drafting room of the Naval Gun Factory. Unlike the ordinary drafting room that every manufacturing plant maintains in connection with its works, this particular one was established with the primary object of being the main design section of the Bureau of Ordnance. It comprised a number of highly skilled ordnance engineers and designers, whose ability and experience enabled the bureau to accomplish successfully some of its biggest tasks during the war.

At the outbreak of war the gun factory, already working to full capacity in some of its shops, was pressed to the maximum in all its activities. Throughout the entire war period work was continued at full blast and a great amount of most valuable ordnance material for the Navy was produced. In addition, the expansion of the gun factory was carried out with greatest expedition, and before the armistice a number of important new branches were in operation.

The most important work and improvements of the gun factory may be summarized as follows:

(*a*) More than 300 guns were manufactured, many more were partially manufactured, and others were relined and rebuilt. These guns varied in size from the 16-inch 50-caliber to the small 3-inch boat gun and the 1-pounder. Nearly 3,000 guns furnished by outside contractors were star-gauged, examined, and put in condition for service.

(*b*) Breech mechanisms were manufactured for all the guns made at the gun factory as noted above, a large number of spare breech mechanisms were made and many others were overhauled, modified, repaired, and spare parts manufactured to supply the needs of the service.

(*c*) Some 500 gun mounts, also ranging from 16-inch to 1-pounder, were manufactured. Over 3,000 mounts as manufactured by outside

VIEW OF 14-INCH 50-CALIBER GUN ON GIRDER IN GUN SHOP, NAVAL GUN FACTORY, WASHINGTON, D. C.

248–1

mand in the battle fleet at sea. The assistant superintendent, Capt. A. L. Willard, succeeded to the superintendency and carried the gun factory along to April 30, 1919, when the present superintendent, Rear Admiral A. W. Grant, U. S. Navy, assumed charge. Capt. M. E. Trench was assistant superintendent from October, 1917, to September 12, 1918, when he assumed command of the torpedo station at Newport, being relieved by Capt. D. E. Theleen. In September, 1917, Commander W. W. Smyth was relieved by Commander Harvey Delano in charge of the design and drafting work for the Navy's ordnance matériel.

Without the gun factory the bureau would not have been able to arm the vessels of the merchant marine. The demand for guns, mounts, accessories, and spare parts for ordnance material exceeded all expectation, and it was only by the experience and the ability of the gun factory that such material was manufactured; in addition, the guidance by the gun factory of the manufacturing plants of the country newly undertaking naval ordnance work, proved the salvation of those plants in the early and accurate production of their work. Trained supervisory force was obtainable from no other source.

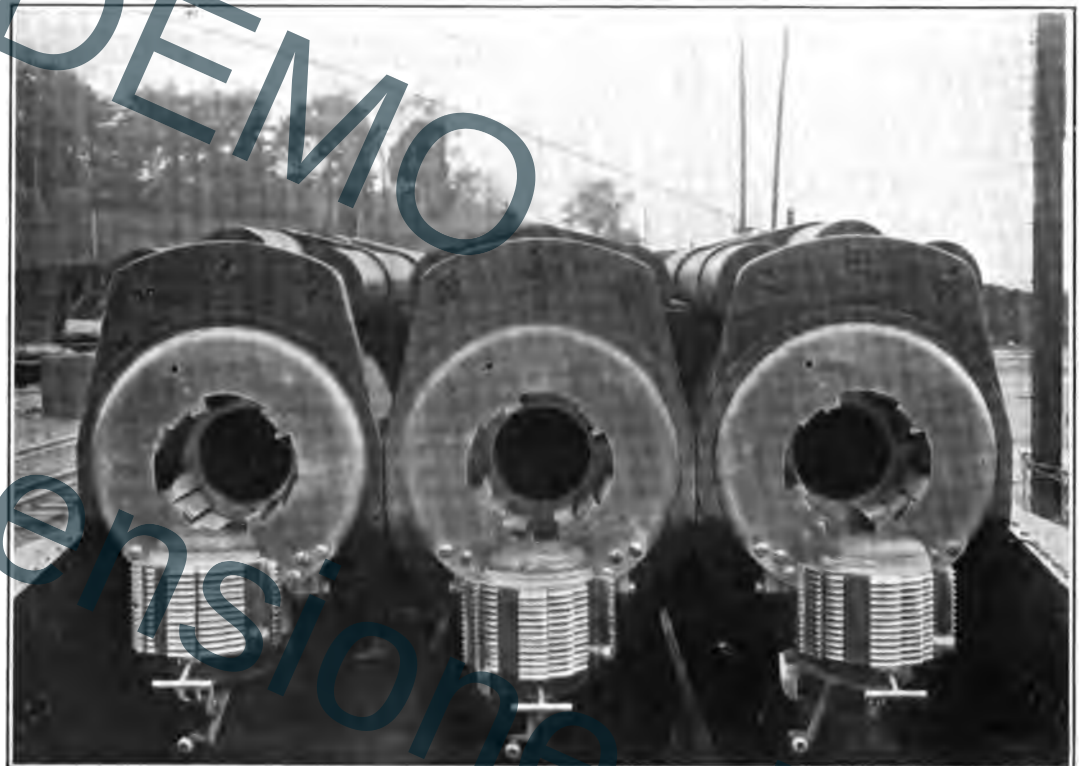
## NAVAL PROVING GROUNDS.

### A.—INDIAN HEAD, MD.

The Bureau of Ordnance has long maintained a proving ground at Indian Head, Md., on the shore of the Potomac River, some 22 miles below Washington. At that proving ground it has tested every gun bought for the Navy, as well as specimen samples of every lot of powder, shell, fuses, and cartridge cases. In addition, armor-piercing shell and armor are tested by firing the one against the other.

The increase of proof work from prewar basis to the rush of war-time tests is shown by the comparative figures of the period immediately preceding the war and that subsequent to the inception of war contracts. The following tables give these comparisons:

| | Fiscal year. | | |
|---|---|---|---|
| | 1916-17 | 1917-18 | 1918-19 |
| Guns: | | | |
| Major caliber | 45 | 33 | 44 |
| Intermediate | 299 | 851 | 3,063 |
| Minor caliber | 150 | 235 | 344 |
| | 494 | 1,119 | 3,451 |
| Smokeless powder ... pounds | 337,779 | 558,168 | 831,033 |
| lots | 212 | 263 | 522 |
| Primers ... lots | 1,500 | 1,789 | 1,970 |
| Cartridge cases ... lots | 346 | ........... | 1,271 |



THREE 14-INCH 45-CALIBER GUNS ON ONE SLIDE AS MOUNTED ON ARIZONA AND PENNSYLVANIA. READY FOR TEST AT PROVING GROUND.

250–1

RANGING BATTERY IN THE VALLEY AT PROVING GROUND, INDIAN HEAD, SHOWING GUNS OF LARGE CALIBER, OBSERVATION PLATFORMS, AND, AT THE RIGHT, A GANTRY USED FOR TRANSPORTING GUNS.

SMALL-CALIBER GUNS IN THE WEST BATTERY AT PROVING GROUND, INDIAN HEAD, MD.

The obstacles to the accomplishment of such increases in the tests were not alone those of pure quantity of material to be tested. Space was the prime and most serious difficulty.

It is not possible to move a proving ground within a short limit of time. The great amount of structural work that goes with gun mounting, and plate or projectile testing, entails a long period of preliminary construction. It was deemed impossible, therefore, at the beginning of the war to entertain any idea of immediate transfer of proof activities to another site. The proving ground itself—that is, the area on which ordnance material may be tested, is in the shape of an isosceles triangle, roughly 800 by 400 feet. This is termed the "valley." Topographical advantages of high surrounding land, well wooded, made it possible to carry out a portion of the desired tests, but even these endangered surrounding buildings and inhabitants. But these very advantages of the ground made lineal expansion practically impossible.

The problem then was to increase the battery dimensions without permitting firing beyond the limits of the valley proper. This was done in two ways: First, the number of batteries was increased to four, firing in two general directions, up and down the river, and overlapping one another. By their relative situation these batteries were named the North, South, East, and West batteries. Special shelters had to be built, new and extraordinarily stringent rules had to be put in force, and an intricate system of transportation had to be devised. Within a few weeks after the declaration of war, practically an entirely new lot of batteries was in commission, and the proving ground was handling as many barges, loaded with guns, as there had been guns themselves previous to the war.

In order to provide storage space for the great quantities of material arriving for test, new magazines had to be built, and new platforms for shells, new areas cleared for parking guns, and new housing for perishable material of every sort. The great mass of this construction work was done by the valley force itself by snatching moments between the various performances of routine proof.

It was found that many items of equipment that were satisfactory in peace time could not carry the strain of war speed. An example of this was the type of butts in use. Prior to the war, a few plate or shell tests a month permitted easy renewal of butt forms. When tests multiplied to several in a single day, it became necessary to contrive a butt structure that would withstand attacks over a long period without serious repair other than simple blocks and wedges. The proving ground succeeded in producing a butt which was nearly permanent and eminently satisfactory.

As continual proof work in the daytime gave little opportunity for transfer of guns, projectiles, and the other materials it was necessary to work in shifts. In this way the actual proving-ground work rarely ceased entirely throughout the 24 hours. Officer personnel attached to the station at the beginning of the war was in no way adequate to the situation. To fill vacancies and create leaders for each branch of proof work a number of Reserve officers of the technical class were broken in by a short course of specialized instruction. Thereafter, the bulk of proof work was done by either reserve or temporary officers under the direction of a handful of regular officers.

The advent of the war developed such an increase in experimental ordnance that on June 30, 1917, this work was placed under one officer under whom various assistants were appointed from time to time as the work demanded more personnel. Owing to the increase in routine proof work, the actual conduct of experiments was at all times difficult because of lack of adequate facilities.

The work done on experimental ordnance during the war covers such a wide field that the subjects can be mentioned only in a general way. The following subjects were investigated, some completely and others along some particular line:

Guns: Machine, howitzers, aero, twin mounts, Davis.

Shell: Asphyxiating, high capacity, 16-inch A. P., line carrying, nonricochet, smoke; test on premature bursting of.

Explosives: Tetryl, TNT, mines, guncotton, various shell fillers, explosive D.

Fuses: A large number of experimental fuses of various manufacture were tested.

Miscellaneous: Aerial bombs, directorscope, caissons, incendiary bombs, subaqueous pressures, primers, erosion, tracers, gas-masks, inclined impacts, experimental armor, detonation tests, gas ejector, type powders, ammunition stowage, tests of service material under certain war conditions.

During the war the proving ground was commanded by Capt. H. E. Lackey, U. S. N., assisted by Commander C. W. Mauldin, U. S. N., as second in command; Lieut. Commander C. L. Lothrop, U. S. N., as proof officer, and Lieut. Commander A. G. Kirk, U. S. N., as experimental officer.

### B.—DAHLGREN, VA.

For some years prior to the war, the bureau had realized that the naval proving ground at Indian Head was inadequate to care for the increasing proving work, first because its area was limited, and second because the straightaway water range down the river was too short for the testing of modern guns. Appropriations were lacking, however, to secure another proving ground, and it was not until the war that the bureau was able to purchase some 1,366 acres of land at Machodoc Creek, Va., an additional 97 acres was acquired by the

THE "VALLEY" AT INDIAN HEAD, SHOWING UPPER END OF NORTH BATTERY IN THE FOREGROUND AND ARMOR AND SHELL TESTING BUTTS IN THE BACKGROUND ON THE RIGHT.

The congestion along the railroad tracks at the left made difficulties for the transportation force.

MEDIUM CALIBER BATTERY, LOWER PROVING GROUND, DAHLGREN, VA.

FUSE-TESTING BATTERY, LOWER PROVING GROUND, DAHLGREN, VA.

252-2

NITRATING PLANT, POWDER FACTORY, INDIAN HEAD, MD. BLENDING TOWER MAY BE SEEN IN THE UPPER RIGHT-HAND CORNER.

252-3

POWER PLANT FOR THE VARIOUS UNITS OF THE POWDER FACTORY, INDIAN HEAD, MD.

252-4

252-5

ETHER HOUSE, SHOWING DRYING HOUSES IN THE BACKGROUND, POWDER FACTORY, INDIAN HEAD, MD.

WEAK ACID MIXING BOXES, PREHEATER HOUSE, FILLER, AND BLOWER HOUSE, POWDER FACTORY, INDIAN HEAD, MD.

purchase of Blackistone Island, and to begin thereon the construction of a great and complete proving ground. A complete battery of guns of all sizes, firing down a clear water range of nearly 90,000 yards, was planned, in addition to extensive armor butts and fuse batteries, and the necessary quarters and administration buildings.

This proving ground was assigned under the command of Capt. Lackey, and directly under the charge of Lieut. Commander S. A. Clement, U. S. N.

Construction was started on May 28, 1918, and before the end of the war a fuse battery had been set up and the pressure of work at Indian Head in that line had been materially relieved. Since the war the construction of the station has continued, and when completed this proving ground will enable the bureau really to progress in all ordnance lines.

## POWDER FACTORY.

With the adoption of smokeless powder for our Navy in 1899 there arose the question of facilities for its manufacture. The Du Pont Co., at Carney's Point, Haskell, and Parlin, N. J., were the main manufacturers, there being also a very small Navy experimental plant at Newport, R. I. The Navy Department established its own powder factory at Indian Head, adjoining the naval proving ground, with the prime object of decreasing the cost of powder, increasing its stability and bettering its quality. This factory was increased from time to time until at the outbreak of the war it was able to turn out 20,000 pounds of powder per day. This rate had been sufficient to keep the Navy supplied with target-practice ammunition and with about one-half of the powder required for service outfits for the Navy, the remainder being bought by contracts.

With the enormous expansion of powder needs during the war, the Navy placed outside contracts and also undertook greatly to enlarge the capacity of Indian Head.

The expansion plan adopted provided for a capacity of 60,000 pounds per day of air-dried powder, with an increase to 80,000 pounds or 100,000 pounds when the additional amount was dried by the water process. E. I. du Pont de Nemours Co. planned and erected the required sulphuric and nitric acid plants, accomplishing this work in ample time despite unusual difficulties. The factory was less fortunate in all its other projects under the expansion plan, and they were still uncompleted at the close of hostilities.

In addition to its normal functions, the powder factory was called on to furnish additional technical force for inspection duty in connection with purchase of explosives; and the laboratory was practically a training school for these men. The laboratory was also called upon to make final inspection of all outside purchases of explosives, involving an increase of 400 per cent in powder work and 600 per cent in explosive work.

A quantity of nitrate of soda ordered for the station was diverted to allied countries and, as the war went on and it became more and more difficult to secure nitrate from Chile, it became extremely desirable to build a nitrogen fixation plant to meet the needs of the Navy. Indian Head was chosen as the site for the plant to supply this station, and work on this plant had just started when the armistice was signed and the contract was canceled.

During the war, as for many years before, the powder factory was superintended by Powder Expert G. W. Patterson, acting under the inspector of ordnance in charge of the proving grounds.

## NAVAL TORPEDO STATIONS.

### A—NEWPORT, R. I.

The naval torpedo station at Newport, R. I., was the first establishment of this character built in the United States. It has long been the Navy's primary station for torpedo design, development, and experimental work. At it all torpedoes are proved and torpedo outfits assembled before issue. In addition to torpedo work, mine, primer, and fuse experimental work and manufacture is carried on. A large torpedo factory is operated in conjunction with the other facilities. The torpedo schools, for training of both officers and men, are located at and operated by the torpedo station, Newport.

The war threw an extraordinary increased burden upon the torpedo station, principally as regards the assembly and issue of material.

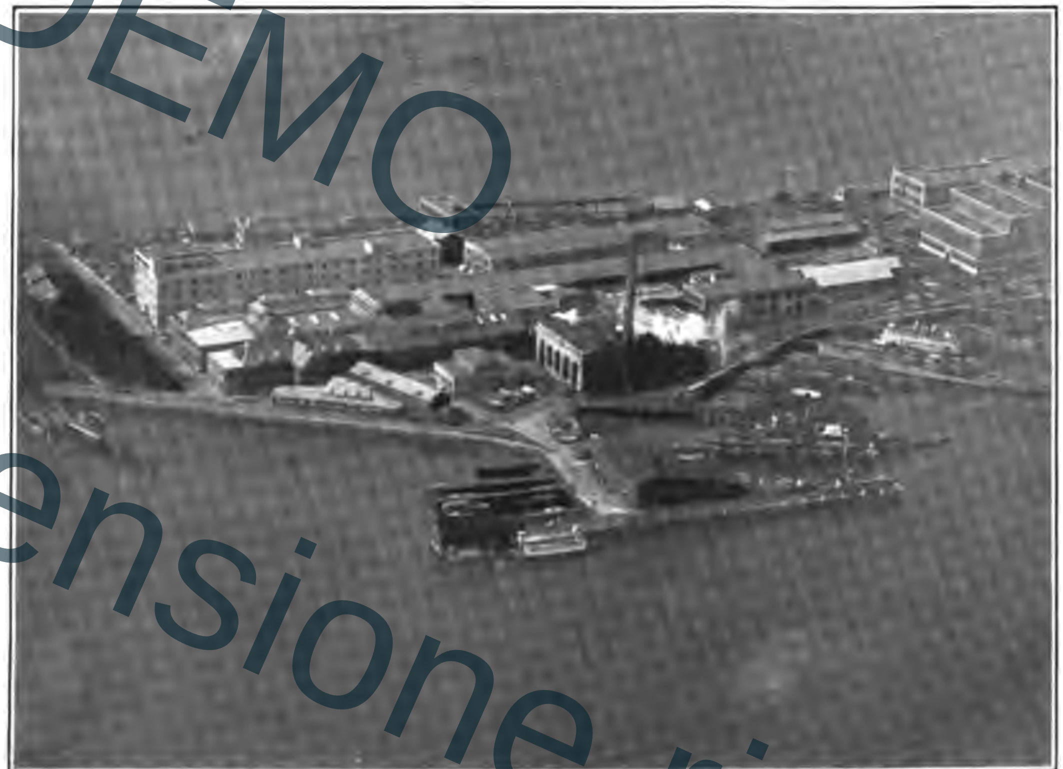
The following summary of activities for the fiscal years 1917, 1918, and 1919 is given as representative of the increase in activities and importance of this station during and immediately after the war:

| | Fiscal year. | | |
|---|---|---|---|
| | 1917 | 1918 | 1919 |
| Torpedoes manufactured | 237 | 248 | 302 |
| Torpedoes received | 186 | 512 | 1,169 |
| Torpedoes issued | 552 | 388 | 1,735 |
| Torpedoes repaired | 330 | 533 | 508 |
| Shots fired on range | 1,674 | 2,130 | 997 |

In addition to the above, manufacture of torpedo air plant, separators, and mines; loading of war heads, mines, and depth charges; manufacture of primers, fuses, spare parts, and mechanisms was carried on.

Experimental work of a highly valuable and confidential nature was done. It was here that the design for the American depth

254-1



INDUSTRIAL PORTION OF U. S. NAVAL TORPEDO STATION, NEWPORT, R. I.

charge was made and the test of these depth charges carried out. Earlier tests in the development of the Mk. VI mine, as used in the Northern Barrage, were made. A number of other experiments with torpedoes, mines, and depth charges were carried out, and this station may be considered the primary testing station for *underwater* weapons, as opposed to the naval proving grounds where *ballistic* weapons are tested.

A large amount of loading of mines, depth charges, and bombs with high explosives was carried on at the station. Despite the fears of the authorities of the city of Newport, no untoward incident occurred throughout the war in connection with the concentration of high explosives for this loading and the loading itself.

Capt. J. K. Robison was relieved, in order that he might go to sea, on March 26, 1917, by Capt. E. L. Beach, who, also leaving for sea duty, was relieved on September 12, 1918, by Capt. M. E. Trench. The station has progressed steadily under these officers, and the advances in the torpedo have been more marked than during any other period in the Navy's history.

### B—PACIFIC COAST STATION, KEYPORT, WASH.

This station was equipped only to store and overhaul torpedoes, and to effect minor repairs. During the war, the transfer of activities to the Atlantic Ocean removed most of the ships carrying torpedoes which had been based on the Pacific coast, and in consequence very little other than minor routine work was carried on at this station.

### C.—TORPEDO ASSEMBLY PLANT, ALEXANDRIA, VA.

As has been noted in the chapter on torpedoes, the bureau appreciated during the war that the existing torpedo facilities in this country were not capable, even with all possible expansion, of meeting the Navy's need for torpedoes. Accordingly, in August, 1918, the purchase of a site in Alexandria, Va., and the construction of a torpedo assembly plant thereon, at a total cost of $2,760,000, was authorized, and soon begun under the direction of Capt. W. S. Miller, United States Navy.

This plant was to be able to completely assemble and test torpedoes, including machining and finishing air flasks and a number of parts.

Although the armistice was signed before the plant was completed, construction has been continued and the existence of this plant, together with other torpedo-manufacturing facilities in this country, will meet all future needs of the Navy for torpedoes which can at present be visualized.

## MINE DEPOTS.

### A.—NEW LONDON, CONN.

Shortly after the outbreak of the war the bureau commenced construction, on a site adjacent to the submarine base at New London, Conn., of a small mine depot for the storage of some 3,000 mines, of which existing war plans called for the concentration in that vicinity. Chief Gunner Frank C. Messenger, United States Navy, was placed in charge, and construction carried on until eleven storage buildings were completed and filled with depth charges and mines.

By that time, however, the notable advance in mining described in the chapter on the Northern Barrage had taken place, and the need was felt by the bureau for a far greater mine depot.

### B.—YORKTOWN, VA.

The establishment on the Atlantic coast of a mine depot, at which practically all mining activities would be concentrated, was decided upon by the Bureau of Ordnance in the spring of 1918. There was no plant then existing in the United States where mines being manufactured could be stored, assembled, loaded, tested, and issued to the service in quantities sufficient to meet any demands of war. After a study of possible sites had been made, a tract of land about 4 miles square, in the vicinity of Yorktown, Va., was selected in April, 1918, as the best location. The considerations which led to this selection included the following:

(*a*) Yorktown is centrally situated with respect to the Atlantic coast of the United States.

(*b*) Yorktown is very accessible for naval vessels of any size or draft, being as convenient to the Chesapeake Capes as is the navy yard, Norfolk; and, while accessible, it can be most readily protected from enemy attacks of whatever description.

(*c*) Yorktown is conveniently located near the Norfolk Navy Yard, the naval operating base at Hampton Roads, and the fuel bases of the fifth naval district.

(*d*) Yorktown is located in a very sparsely inhabited district; therefore the large area of land necessary to the establishment of a mine and high-explosive depot could be obtained at a reasonable cost, and great quantities of high explosives could be stored and handled there without risk to outside life and property.

(*e*) Excellent transportation facilities could be readily developed. The area selected had a water front on the York River of about 5 miles and extended inland to the main line of the Chesapeake & Ohio Railroad.

MINE STORAGE BUILDINGS UNDER CONSTRUCTION AT NAVAL MINE DEPOT, YORKTOWN, VA.

MINES STORED IN THE OPEN AT NAVAL MINE DEPOT, YORKTOWN, VA., AWAITING COMPLETION OF STOREHOUSES.

MINES RECEIVED AT NAVAL MINE DEPOT, YORKTOWN, VA. WAITING COMPLETION OF STORAGE BUILDINGS.

TEMPORARY RAILROAD PIER AT NAVAL MINE DEPOT, YORKTOWN, VA., FOR RECEIPT AND SHIPMENT OF MINES.

The title to the land for the mine depot, 11,433 acres, comprising a part of each of the counties of York, James City, and Warwick, was taken by presidential proclamation dated August 7, 1918, While it was not possible to draw up definite plans for the establishment of the depot until after the title to the land had been secured, some work had been accomplished in that direction, and construction began in September, 1918.

Although this depot was not completed during the war to such a degree as to be of any value, yet its necessity was so apparent that construction in full is being continued, and a description of this depot, built as a result of the bureau's activities in the war, may well be of interest. Commander S. P. Fullinwider, then of the Mine Section of the bureau, originated the project of such a depot, assisted in the selection of the site, and in June, 1919, was at his request transferred from the bureau to command of the depot, relieving Capt. E. T. Fitzgerald, R. F., who had commanded up to that date.

Construction of the mine depot includes a mine-loading plant, consisting of several buildings, 10 magazine buildings for the storage of high explosives, five storage buildings for mine and depth charge material, a nonmagnetic building, barracks, mess buildings, administration buildings, a pier, a power plant, a machine shop, a railroad, to connect with the Chesapeake & Ohio Railroad, vehicle roads, a telephone system, water and fire protection systems.

The five storage buildings of the depot are designed to contain more than 50,000 mines and anchors, which, except for a small supply ready for instant use, will be kept unloaded.

The 10 magazines for high explosives, each capable of storing 1,000,000 pounds, are spaced about one-half mile apart in an area 2 miles square, leaving a border of unoccupied ground about 1 mile wide on all sides, including the water front. No construction, except the railroad, was planned for this safety zone; and any possible explosion in the depot will not seriously damage adjacent property.

The pier as designed is 2,000 feet in length, allowing seagoing vessels of deep draft to come alongside. The railroad track is carried to the end of the pier in order that mine planters and other vessels may be loaded and unloaded with facility.

The cost of the mine depot will be about $3,000,000, and a special appropriation for this amount was made at the time the depot was planned.

The personnel at the mine depot comprises officers and enlisted men of the Navy and Marine Corps and additional civilian labor. All patrol and sentry duty is performed by marines.

The first carload of material to be stored at the mine depot was received the latter part of July, 1919. At that time the storage buildings were nearly completed, although much work remained in connection with the other facilities.

When the depot is complete, it will have the following activities:

(*a*) It will store about 80 per cent of all mine and depth charge material.

(*b*) In conjunction with the mine force, it will be the "mine proving ground" for practical tests and experiments.

(*c*) In conjunction with the mine force, it will be a school for instruction of officers and men in mining.

(*d*) It will be an assembly plant for loading, assembling, inspecting, testing, and issuing mines to the mine force ready for use.

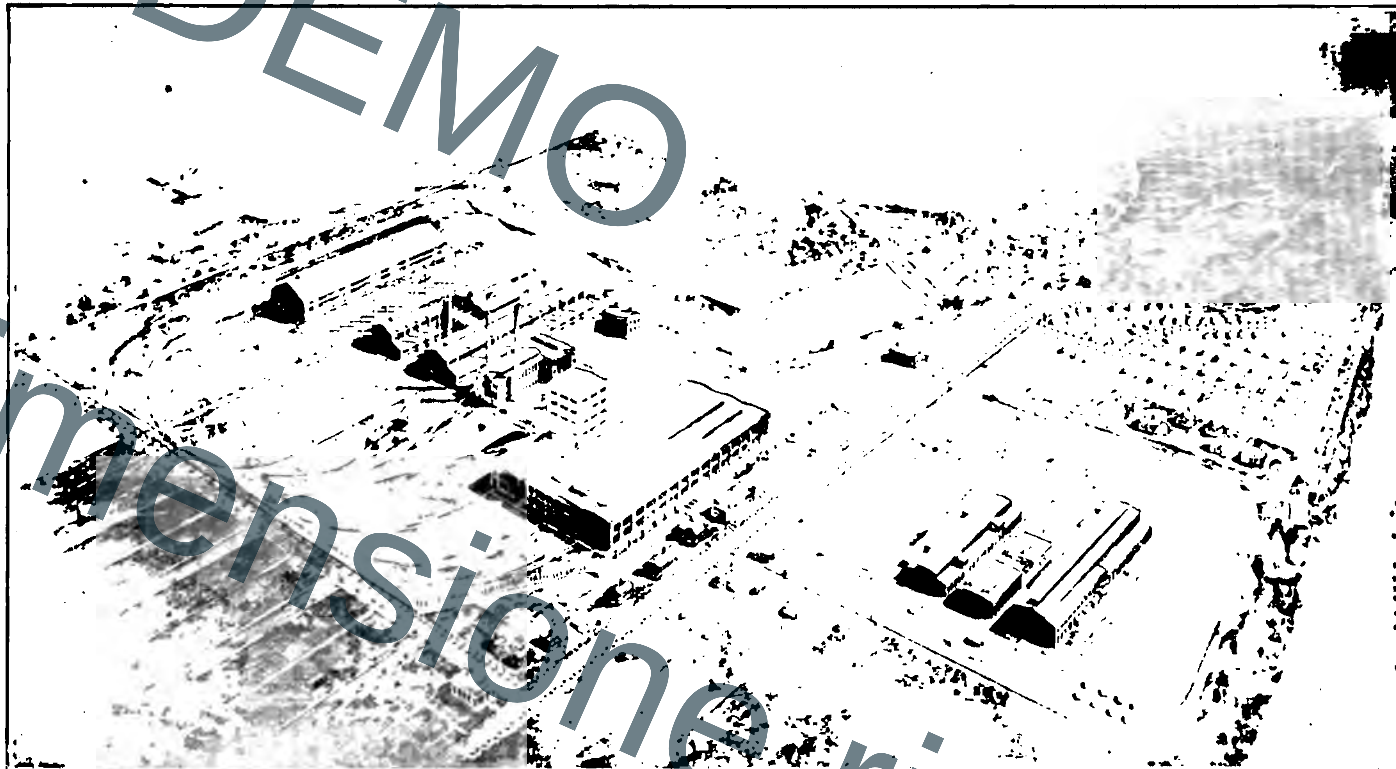
### NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

In order to provide additional facilities for the manufacture of armor for naval vessels, the Navy Department recommended some years prior to the war the construction of a naval armor plant, and Congress authorized such construction and made initial appropriations therefor. The Secretary of the Navy appointed a committee to select the site for such a plant; and, after examination of a number of suggested sites, it was decided April 24, 1917, to build the plant near Charleston, W. Va. In other words, the selection of the site of this plant was made practically coincident with the entry of the United States into the war. The complete project consisted of a single plant in which guns, armor, and armor-piercing projectiles were to be produced, with an aggregate annual capacity of approximately 40,000 tons.

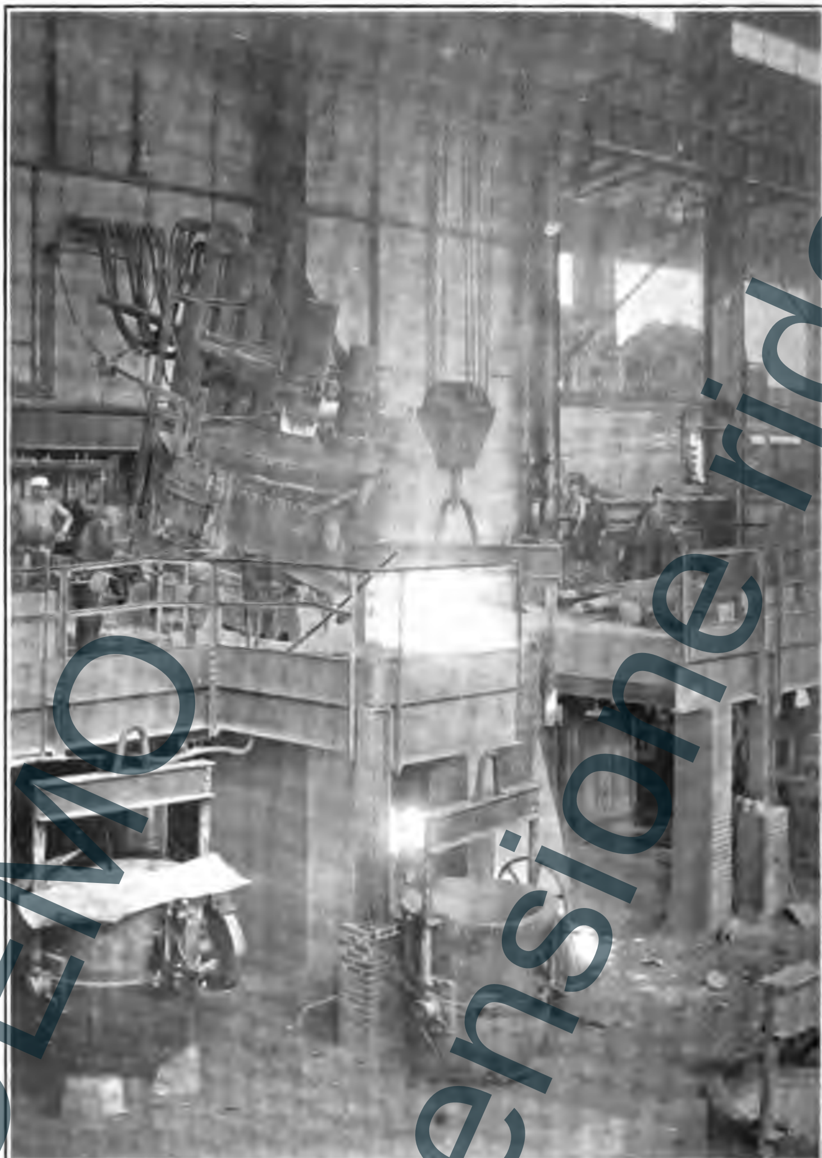
Two facts were at once apparent, however; first, that due to the need of the Allies for small vessels rather than battleships, there would be no immediate expansion in battleship building by the United States, consequently no immediate need for additional armor; second, that all available capacity was urgently needed for small gun forgings.

A site containing 210.091 acres at South Charleston, W. Va., was selected for the plant. The Chamber of Commerce of Charleston, W. Va., purchased 205.391 acres of this area for the sum of $290,-845.68 and donated it to the United States. The remaining 4.7 acres was acquired by condemnation proceedings for the sum of $64,047.25, of which amount the chamber of commerce paid the sum of $19,895.32 and the remaining $44,151.93 was paid by the Government.

From the above it is disclosed that the entire area of 210.091 acres was acquired for the total sum of $354,892.93. Of this amount the



U. S. NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.



ELECTRIC FURNACE, NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

258-2

258-3


GUN-STEEL INGOTS MADE AT U. S. NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA., WITH HERCULT ELECTRIC FURNACES, 1918-19.

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GUN SHOP NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

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FORGE SHOP, NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

# INDEX.

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