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The Coast Artillery Journal

Vol. 59 No. 1 JULY, 1923 Whole No. 203

The Campaign of Coronel and the Falklands August 1, 1914, to March 14, 1915

By Captain Edward S. Kellogg, U. S. Navy

The second in a series of historical studies at the Army War College, made available through the courtesy of the Commandant and of the author.

THE Battle of Coronel, November 1, 1914, and the Battle of The Falkland Islands, December 8, 1914, were the culminations of the cruiser warfare which was carried on during the first months of the Great War and cannot properly be appreciated without study of the entire field and the events leading up to and following the battles.

OUTLINE OF HISTORY

General Situation

When Great Britain entered the war August 4, 1914, France and Russia had been at war with Germany since August 1, 1914. During the period of strained relations, preparations were made and instructions issued to protect trade routes, to stop the enemy trade and to destroy the enemy forces on foreign stations.

In general, the plan adopted was to warn shipping of the opening of hostilities, to route cargo shipping according to information received, but without escort, to escort troop ships in convoy, to divide the trade routes into sections and to provide each section with a force to furnish escorts, to patrol local points with a view to destroying enemy cruisers, and to capture enemy shipping. At the outbreak of hostilities the home fleet covered the North Atlantic and approaches to the British Isles. In the Mediterranean were three battle cruisers, four armored cruisers, four light cruisers, and a torpedo flotilla, together with most of the French Navy. In more distant seas there were a battle cruiser, two old battleships, six armored cruisers and seventeen light cruisers with a proportion of torpedo craft. Thus there was a total of thirty-one British vessels of strength in foreign waters.

The Mediterranean squadron covered the trade routes from Suez to Gibraltar; the China squadron covered the China coast to Singapore and the Malay Archipelago; the East Indies squadron covered from Singapore to Aden, the Arabian Sea and the Bay of Bengal; the Australian division covered Australia to Aden and the southern part of the Malay Archipelago and the Western Pacific, and the New Zealand division, New Zealand to Australia.

On the Cape of Good Hope Station were three light cruisers to cover the East African trade. The North American squadron covered the West Indies and Atlantic Coast of North America. One light cruiser covered the South American station and two light cruisers the North Pacific on the American coast.

The German battle cruiser *Goeben* and light cruiser *Breslau* were in the Eastern Mediterranean. The German Pacific squadron, two armored cruisers and three light cruisers, was based on Tsingtau, China. Two light cruisers were in the West Indies and one on the east coast of Africa, a total of ten vessels of strength, in foreign waters.

British Movements

Cruiser squadrons from the home fleet were, immediately upon the declaration of war, sent out to cover the North Atlantic routes to North America, the routes from the Channel to Madeira, the ends of the Oriental and Cape routes and the Cape Verdes. The North American squadron was reinforced. French and Russian cruisers everywhere joined with the British to protect the trade routes. At least thirty-eight vessels were added to the original forces, making a total of sixty-nine. In addition, a number of merchant vessels were equipped and commissioned as auxiliary cruisers.

The enemy disappeared. The *Goeben* and *Breslau* evaded, reached Constantinople, and were sold to the Turkish Government. The German Pacific Squadron abandoned Tsingtau and disappeared before Great Britain entered the war. The two German cruisers in the West Indies disappeared. The *Konigsberg*, based on Dar-es-Salaam, the capital of German East Africa, disappeared.

On August 23d Japan entered the war and her cruisers, about thirty of all classes, were immediately thrown in with the Allies in the protection of the trade routes.

At this time, therefore, there were at least one hundred vessels engaged in this work.

Tsingtau was captured and one by one the German bases and wireless stations in the Pacific Islands and on the East coast of Africa were taken.

Suddenly after a period of silence, word began to come in of merchant vessels being destroyed or captured off the coast of Brazil, in the Arabian

Sea, the Bay of Bengal, and off the West Coast of North America. The news was usually a week or so late and search of the reported areas failed to locate the enemy.

Enemy trade was stopped, but Allied trade proceeded with occasional halts, and some loss. Troop movements were slightly interrupted.

The elimination of the *Goeben* and *Breslau* on August 12th released part of the Mediterranean squadron, the battle cruisers returned to the home fleet and several of the other cruisers reinforced the squadrons in the Atlantic and east of Suez.

The available information indicated by August 15th, that the German cruisers in the Atlantic—the *Dresden* and *Karlsruhe*—were moving to the South. In consequence, Admiral Craddock of the North American Squadron was relieved and sent South after them. By the end of September he was based on the Falkland Islands with the *Good Hope*, *Monmouth*, *Glasgow*, *Otranto* (auxiliary) and the old battleship *Canopus* immediately under his command and the Cape Verde squadron as part of his command operating off Northern Brazil. The *Karlsruhe* remained quiet and the *Dresden* was heard of off the west coast of South America.

The *Emden* of Admiral Von Spee's squadron was identified as the cruiser operating in the Bay of Bengal.

From time to time news was received of the location of Admiral Von Spee's main force—the armored cruisers *Scharnhorst* and *Gneisenau*—and on October 7th Admiral Craddock was informed that the Germans were concentrating at Easter Island and was directed to concentrate his force on the Chilian coast. The force under his immediate command moved into the Pacific and at the same time he ordered the powerful armored cruiser *Defence* of the Cape Verde squadron, to join him with all speed and informed the Admiralty of his action. His orders to the *Defence* were countermanded by the Admiralty and on the evening of November 1, 1914, he was met by the German Squadron. The *Good Hope* and the *Monmouth* were sunk with all on board and the other vessels of the force escaped to the east coast and on December 7th concentrated with powerful reinforcements at the Falkland Islands. The German Squadron appeared on December 8th and was destroyed with the exception of the *Dresden* which escaped into the Pacific and carried on operations until March 14, 1915, when she was destroyed at anchor in Cumberland Bay, Juan Fernandez, by three British cruisers.

The *Konigsberg* was blockaded in the Rufiji River, east coast of Africa, October 30th, 1914, and was later destroyed.

The *Karlsruhe* completely disappeared about November 2, 1914 and after the war it was learned that she was destroyed by an accidental explosion off the north coast of South America on November 4, 1914.

On November 9, 1914, the *Emden* raided Cocos Island in the Indian Ocean. On the same day and as a result of the raid, she was met and destroyed by the Australian cruiser *Sidney*.

With the exception of an occasional strike by an isolated auxiliary raider, the cruiser warfare ended with the destruction of the *Dresden* March 15, 1915, but all vessels of importance were able to reinforce the Grand Fleet immediately after the Battle of the Falklands, December 8, 1914, five months after war was declared.

The Allied shipping losses during the first six months of the war due to cruiser warfare were

	43 British ships with a tonnage of....	110,000
	20 foreign ships with a tonnage of....	20.000
Total	63	130,000 tons.

A money loss of possibly $40,000,000.

The naval losses were two armored cruisers and two small old cruisers.

German Movements

At the outbreak of war the *Emden* was in the China Sea, the *Leipzig* on her way to San Francisco, the *Scharnhorst* and *Gneisenau* at Panape, Caroline Islands, and the *Nurnberg* on her way from Honolulu to Ponape to join the flag. On August 12th all but the *Leipzig* concentrated with the *Emden* and train at Pagan Island, Ladrone Islands. The Commanding Officer of the *Emden* persuaded the Admiral to detach him for operations against British trade in the Bay of Bengal, and he entered the Indian Ocean on August 29th, east of Java.

The German Squadron received news of the entry of Great Britain into the war and moved to the Marshall Islands August 22d. The *Nurnberg* was sent to Honolulu for information. News of Japan's entry into the war was received and the squadron moved to Christmas Island mid-Pacific, where the *Nurnberg* rejoined September 8th after cutting the cable at Fanning Island.

On September 14th Admiral Von Spee appeared at Samoa and on September 22d made a demonstration off Tahiti. On October 1st he appeared in the Marquesas Islands and from there proceeded to Easter Island, directing the *Leipzig* and *Dresden* to join him there, which they did by October 14th. This message was intercepted and deciphered by the British and all forces concerned were informed of its contents by October 7th, 1914.

At Easter Island Admiral Von Spee was in communication with the Chilian coast and learned that the Japanese were closing in from the north and the British from the south. On October 18th, having decided to search for the British squadron under Admiral Craddock and destroy it before the Japanese could close in, he proceeded direct for the Chilian coast and met and defeated Admiral Craddock on November 1st,1914, off Coronel, Chili. He remained on the west coast until December 1st, when he rounded Cape Horn and proceeded direct to the Falklands with the intention of capturing the Islands on December 8th. On the same day his squadron was destroyed by the British in superior force.

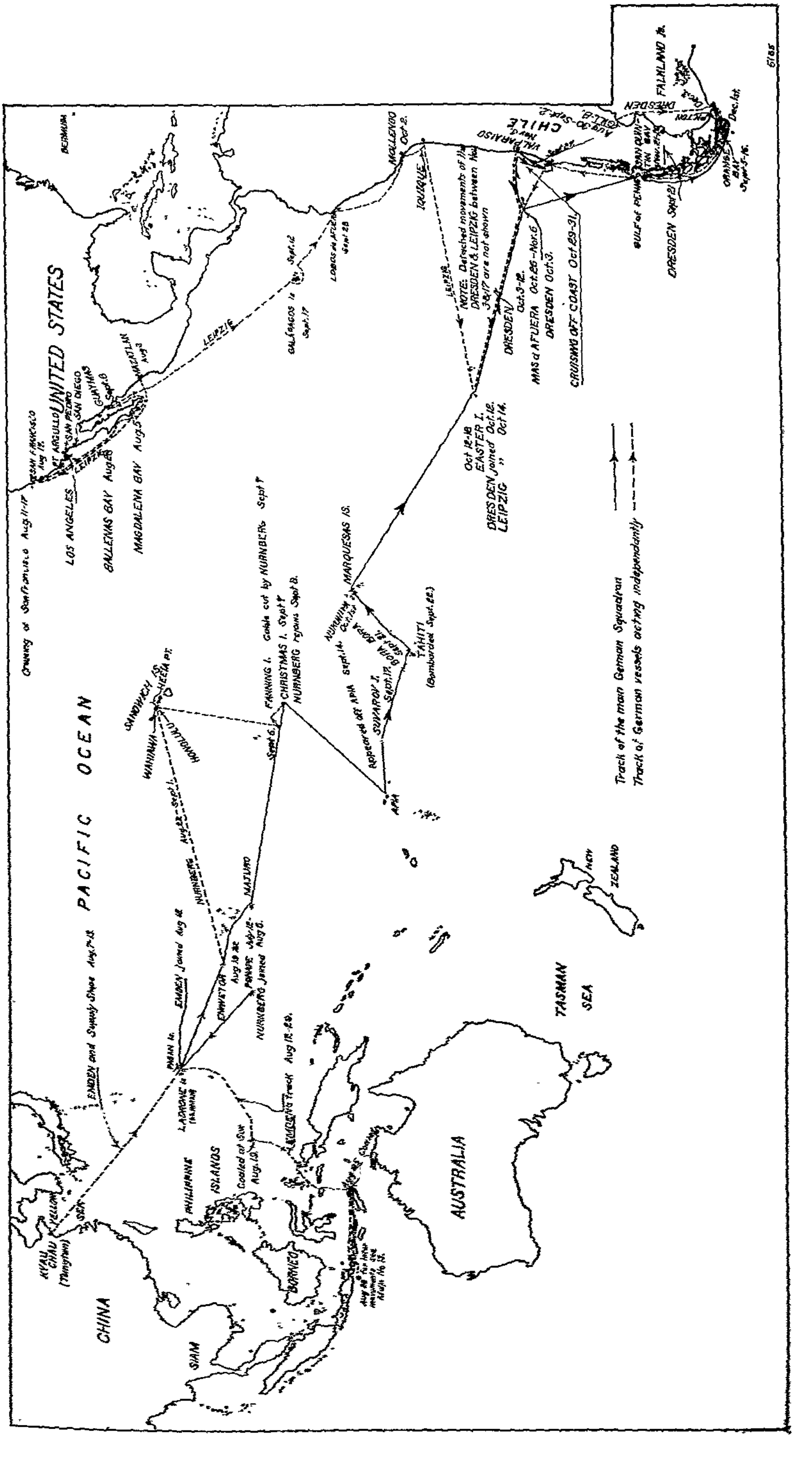

FIG. 1. GERMAN MOVEMENTS

The Battle of Coronel

At the time of meeting, about 4 p. m., November 1st, 1914, both commanders were aware of each other's proximity but each was expecting to meet an isolated unit of the other's force at this particular time, so that the meeting was somewhat in the nature of a surprise. Both squadrons were deployed for scouting, but partly concentrated for the battle.

The forces engaged were the armored cruiser *Good Hope* and *Monmouth*, the light cruiser *Glasgow* and the auxiliary *Otranto* on the side of the British. The *Canopus*, pre-dreadnought battleship, was about two hundred and fifty miles to the south with the train.

On the side of the Germans were the armored cruisers *Scharnhorst* and *Gneisenau* and the light cruisers *Dresden* and *Leipzig*. The light cruiser *Nurnberg* was unable to join until after the battle was decided.

The rated speeds of the two forces were practically equal with a possible slight advantage on the side of the Germans. The British, although rated 23 knots, ran at 17 knots during the battle owing to the heavy sea and the Germans appeared to have used about the same speed.

There was a strong wind and heavy sea from the east of south and both forces formed column heading to the south. The British force by the accident of the meeting was to the westward with the sun setting in a cloudless sky.

The broadside fire of the British was 26 guns of 4-inch and above and that of the Germans 28 of 4-inch and above. The heavy guns were 2-9.2-inch guns on the part of the British and 12 8.2-inch guns on the part of the Germans.

Both commanders decided to attack. The British attempted to close while the sun glare was to their advantage, and the Germans held off until the light conditions were such that they were in shadow while the British were silhouetted against the afterglow.

Fire was opened by the Germans at 6:34 p. m., at a range of 11,260 yards.

The British did not open fire until five minutes later. Meanwhile, the Germans got the range and landed a salvo on the *Good Hope's* forward 9.2-inch gun, putting it out of action.

The heavy head sea rendered all lower-position guns useless and the fire of the few available 6-inch and 4-inch guns in high positions, was ineffective at the opening ranges.

The fight was practically one 9.2-inch gun against twelve 8.2-inch and the results were inevitable. The *Good Hope* blew up at 8:20 p. m. and the *Monmouth* was sunk by gunfire at 8:56 p. m. The *Glasgow*, badly damaged, and the *Otranto*, escaped.

The German ships were newer, better protected, and their guns more modern than the British.

The British crews were reservists and not as well trained in gunnery as the Germans.

The conditions did not permit the British to maneuver for better position, but they could probably have withdrawn and concentrated

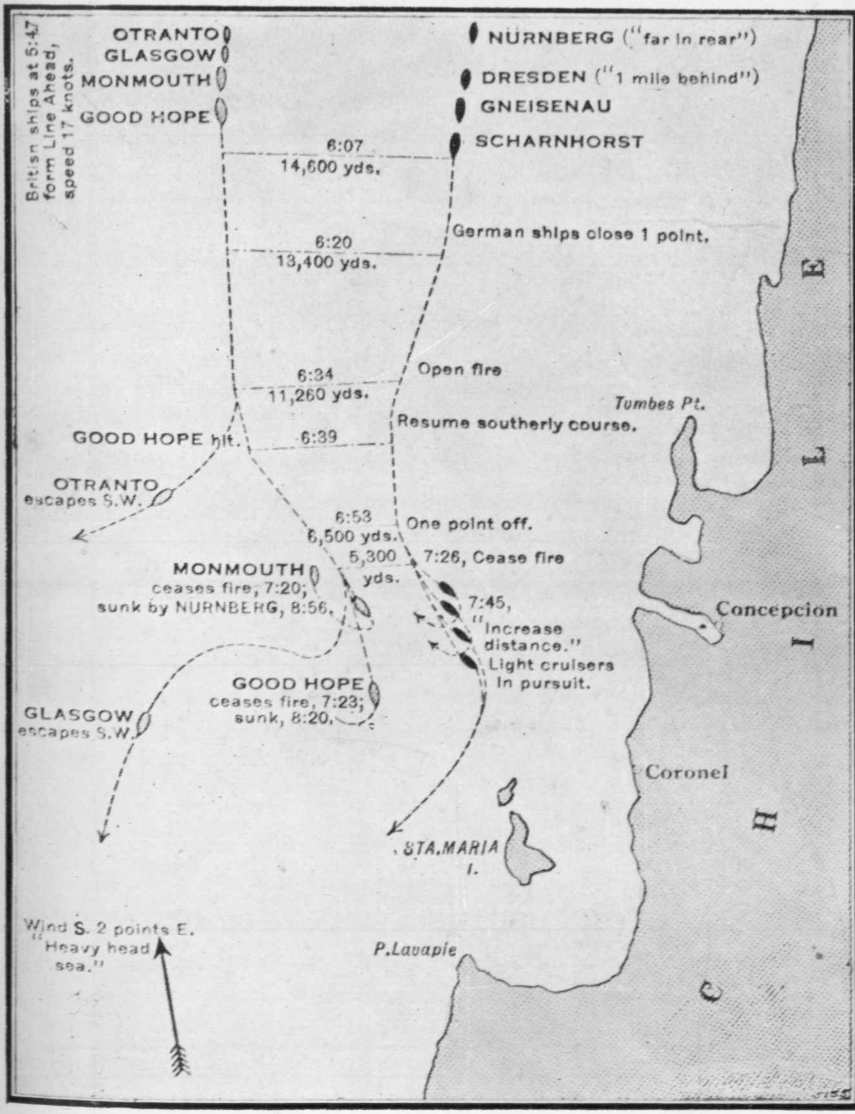

FIG. 2. THE BATTLE OF CORONEL

with the *Canopus* during the night in spite of the 16-knot speed of the *Otranto*.

The damage to the German ships was negligible.

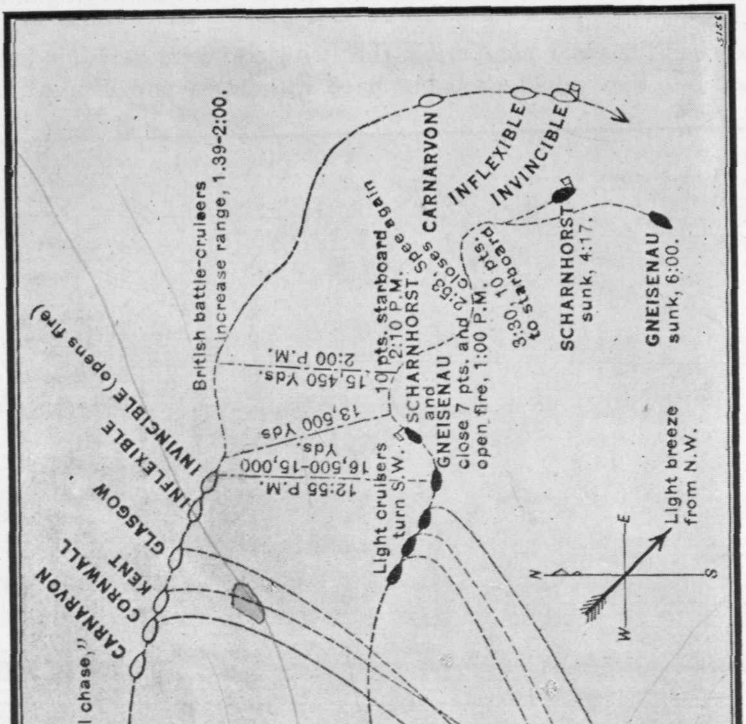

FIG. 3. THE BATTLE OF THE FALKLANDS

News of the battle was known in Europe November 3d and Turkey declared war November 12th.

The German success was probably the deciding factor in drawing Turkey into the war on the side of the Central Powers, and also left the Allied trade with South America (particularly the vital nitrate trade), open to attack for a period of several weeks.

The Battle of the Falklands

Early on the morning of December 8, 1914, the German Squadron of the same strength as at Coronel, appeared, in close formation, off Port Stanley, Falkland Islands, with the intention of capturing the place. During the five weeks' interval since the Battle of Coronel, the British had secretly sent down the battle cruisers *Inflexible* and *Invincible* so that the fight that ensued was decided by sixteen 12-inch guns against twelve 8.2-inch guns and again the result was inevitable. The sea was smooth, the visibility high. The British opened fire at 12:55 p. m., with a range of 16,500 yards. The German armored cruisers opened, five minutes later. The British maneuvered with great caution, holding the Germans at long range. The *Scharnhorst* was sunk at 4:17 p. m. and the *Gneisenau* was sunk at 6:00 p. m.

The light cruisers had a running fight in which the five British cruisers destroyed the *Leipzig* and the *Nurnberg* and captured the train.

The *Dresden* escaped into the Pacific and carried on the cruiser warfare off the west coast of South America until March 15, 1915, when she was destroyed.

STRATEGY

British Strategy

The British violated the principle of the objective in their system of protecting trade.

The true objective, which they apparently failed properly to appreciate at first, was the destruction of the enemy main force, which in this situation was the armored cruisers of Admiral Von Spee's squadron.

In the destruction of those ships lay security for trade and transport. They were the backbone of the cruiser warfare, the force that necessitated the detachment of valuable battle cruisers and armored cruisers from the Home Fleet and sending them away from the main theatre of operations.

As it was vital to the very existence of the nation and the Allied cause to keep trade moving, it was necessary to provide an immediate measure of security. The convoy system would have accomplished this while at the same time forcing the enemy to concentrate and attack, or remain inactive.

The principles of the objective, economy of force, movement, security, simplicity and cooperation would all have been satisfied by the prompt adoption of the convoy system for trade. Next, the immediate dispatch of a number of cooperating units under one command, for the sole purpose of locating and destroying the enemy main force would have satisfied the principles of the objective, the offensive, mass and surprise. Such units eventually appeared but were too slow in coming into being and their activities were not properly coordinated. They cooperated, but lacked unity of command.

The Japanese 1st and 2d South Sea Squadrons, one or both, could have and should have been present, at Coronel. Admiral Sturdees' force could just as well have met Von Spee at Coronel as at the Falklands and should have done so.

The Admiralty was in full possession of the facts in plenty of time to take proper action. Not only did it fail to act, but in countermanding Admiral Craddock's order to the *Defence*, refused to permit him to act. Admiral Fisher becoming First Sea Lord of the Admiralty a day before Coronel, immediately approved Admiral Craddock's order, but it was then too late. Upon receipt of the news of Coronel he sent two battle cruisers to the Falklands, thereby taking a step which should have been taken by his predecessor weeks before.

A study of the situation in the Pacific in September, 1914, shows that it was most probable that the German squadron would gravitate toward the coast of Chili. Superior forces faced it in all other areas. Chili was a sympathetic neutral and large numbers of German subjects lived there. The lonely and unfrequented islands off the coast, belonging to weak powers, made excellent operating bases and the very latest information concerning these islands in the Sailing Directions was furnished by the Germans.

Important Allied trade, partly coal trade, existed in the area, promising fuel and supplies for the squadron. Numerous German merchant vessels were lying in Chilian ports ready to render assistance.

The nearest allied territory, the Falkland Islands, was a thousand miles away and the nearest allied bases of any consequence were 5,000 to 6,000 miles away.

In addition, the progress of the German main force in crossing the Pacific was reported step by step and finally a message was intercepted in early October giving the information that a concentration was to be made at Easter Island.

Twenty-five days after the receipt of this last information the enemy was sought and met with inferior force.

German Strategy

The destruction of sixty-three merchant vessels and loss of $40,000,000 was merely an incident of the cruiser warfare, a result not commensurate with the effort put forth and one which had little or no effect upon the result of the war.

The real achievements were: (a) The withdrawal of over one hundred allied war vessels, about fifty cargo-carriers, one hundred thousand men and not less than $200,000,000 from the main theatre of operations by two armored cruisers, six light cruisers and perhaps six auxiliaries, say fourteen vessels in all, for a period of four months. A rather good example of the correct application of the principle of the economy of force.

(b) By the success at Coronel, drawing Turkey into the war with the resultant attraction of numbers of powerful ships, and large numbers of men from the main theatre of operations to prosecute the Gallipoli Campaign, to say nothing of the general influence upon Bulgaria and the Mohammedan World.

The fact that full advantage was not taken of this success detracts nothing from the achievement.

A study of the facts of the case indicates that still greater results might have been attained by stricter adherence to and more reasoned application of the principles of war.

The campaign as a whole shows many examples of the correct application of the principles, but certain incidents indicate that there was not a complete understanding of them nor of their application, by the German Admiralty and by the Commanders in the field.

Admiral Von Tirpitz in his Memoirs tells us that the German plan for cruiser warfare was wrecked by the entry of Japan into the war and left nothing for the cruisers to do but try to make their way home.

If the plan was correctly drawn this should not have been so and the statement casts doubt upon the ability of the German Admiralty.

The reported statement of a survivor of the *Karlsruhe* to the effect that his Commanding Officer's secret orders were: to war on commerce in Mid-Atlantic independently, the details of such warfare to be left entirely to him; and the poor showing of the *Konigsberg*; indicate lack of doctrine and of understanding of the application of the principles of the objective, mass, unity of command, security, and cooperation.

The true objective of the German Navy was the destruction of the enemy main naval force, for the purpose of contributing to the destruction of his main land force. The general objective of the cruiser force therefore, was the attraction of as much of the enemy force from the main theatre of operations as possible. War on commerce with its subdivisions of capture, destruction, and interruption was a means to the end. Other means were war on transports of troops; and capture, raiding and destruction of outlying possessions.

Considering the weakness in material and personnel of the force, the shortage of munitions, the lack of secure bases, and general lack of supplies and facilities, war on commerce offered the greatest chances of success. The convoy system rendered war on transport of troops hazardous and such war on outlying possessions as was carried out, proved disastrous.

The raiding of Kelung resulted in the immediate destruction of the *Emden;* the demonstrations of the main force in the Pacific Islands gave valuable information to the enemy and wasted ammunition, and the projected attack on the Falklands, resulted in the destruction of the main force.

It would seem, therefore, that under the circumstances these attacks should not have been made, but if we accept them as correct applications of the principle of the objective, then we must criticise the tactics employed.

The attack on the Falklands was a violation of the principle of movement, the objective, mass, economy of force, surprise, and security.

By waiting five weeks after the battle of Coronel before attacking the Falklands, Admiral Von Spee violated the principle of movement and allowed the enemy to concentrate superior force.

By not having the *Emden* with him at the time of the battle he violated the principle of mass By attempting to capture the Falklands and losing his entire force he violated the principles of the objective and economy of force. That act practically ended the cruiser warfare and released many valuable units for duty with the enemy main force.

It is very doubtful if he should have attacked at all, but assuming that he was correct in doing so, then he ought to have done so immediarely after Coronel.

The original wide deployment of the force, if only temporary, was a correct application of the principles of economy of force and surprise.

The independence of the *Dresden, Karlsruhe, Konigsberg* and *Emden* were violations of the principles of unity of command, mass, and security. Better results might have been obtained, even in spite of the difficulties of communication, if all had been under the command of Admiral Von Spee; if minor and major concentrations had been contemplated and tentatively provided for, and all had operated in accordance with a common doctrine.

The *Karlsruhe* operated with auxiliaries and prizes as scouts, never showing herself except to insure captures. This was correct application of the principles of economy of force, surprise, and security. She was on her way to attack Barbadoes when she was accidentally destroyed by an internal explosion. The decision to attack Barbadoes was a violation of the principle of the objective and probably would have resulted disastrously.

The *Konigsberg,* after destroying the *Pegasus* September 20th, violated all principles of war by allowing herself to be blockaded without chance of escape.

It would seem that the best results could have been obtained and the operations continued for a longer period, if the warfare had been confined to commerce and the destruction of inferior forces interfering with the operations, the cruisers never showing themselves except to insure a capture or to destroy an inferior enemy, carrying on all scouting and reconnaissance, and as far as practicable making all captures with auxiliaries and prizes: making occasional major and minor concentrations for attack of enemy inferior concentrations, interfering with the work; making frequent and wide changes of position and visiting only unfrequented and isolated places and then only after careful reconnaissance.

The general plan should have made better provision for munitions, supplies, equipment and men. Had the possibilities of the campaign been fully understood, it would have been a simple matter to have shiploads of such supplies waiting in the South Pacific, the South Atlantic and the South Indian Oceans where they would have been unmolested for months and could have been called when wanted. Many of the vessels that interned and eventually passed into the hands of the Allies could have served a much better purpose. Something along this line was attempted, but the preparations were not made with sufficient foresight or understanding.

TACTICS IN THE BATTLE OF CORONEL

British

There is good evidence to show that Admiral Craddock understood his orders to require him to seek and destroy the enemy. He was fully aware of the inferiority of his cruiser force. He reasoned that the 16-knot speed of the old battleship *Canopus* did not permit her use in running down a 23-knot enemy. Therefore, he used the *Canopus* to guard the train and sought the enemy with his inferior cruiser force.

Apparently the Admiralty never intended this, but gave him the impression that they did.

In attacking, Admiral Craddock was probably influenced by Nelson's statement:—"By the time the enemy has beat our fleet soundly, they will do us no harm this year." (Mahan's Life of Nelson, Vol. 2, p. 306).

Unfortunately for him, all the odds were against Admiral Craddock and neither chance nor skill altered the balance. Had the relative positions of the two forces been reversed and the British more skilful in gunnery, it is possible that they might have inflicted serious damage upon the enemy, in which case the attack would have been justified.

Under the circumstances, the decision violated the principles of the objective, mass, and security.

It would seem that the British as soon as the enemy armored cruisers were sighted, should have concentrated upon the *Canopus*, at the same time endeavoring to keep track of the enemy until superior force could be concentrated.

History shows that the inferior force is often successful in battle, but analysis shows that in each case, skill and chance, or both, have changed the balance so that the apparently weaker force is actually the stronger on the field of battle, or at least at the point of contact.

Chance alone is seldom sufficient, but skill and chance usually walk hand-in-hand.

At the Battle of the Nile, Nelson successfully attacked superior forces without hesitation, but only because he instantly grasped the fact that by chance and skill he could alter the balance to his favor.

At Trafalgar he maneuvered for more than twenty-four hours in the presence of the enemy in order that some of the odds might be turned in his favor. When this was accomplished he successfully attacked superior force. Skill and chance turned the balance here.

Referring to his chase of the French fleet, in 1805, he says:

"I am thankful that the enemy have been driven from the West India Islands with so little loss to our Country. I had made up my mind to great sacrifices; for I had determined, notwithstanding his vast superiority, to stop his career, and to put it out of his power to do any further mischief. Yet do not imagine I am one of those hot-brained people, who fight at an immense disadvantage, without an adequate object." "If we meet them we won't part without a battle. I think they will be glad to leave me alone, if I will let them alone; which I will do, either till we approach the shores of Europe, or they give me an advantage too tempting to be resisted."

German

The Battle of Coronel was, on the part of the Germans, a correct application of the principles of the objective, the offensive, mass, economy of force, security, and simplicity.

The attack and destruction of the enemy's main strength was accomplished with no weakening of their own force except the expenditure of ammunition. The success operated for security and economy of force by disposing of the British Squadron before the Japanese squadrons to the north could appear on the scene.

The general objective of the cruiser force was served by completely exposing Allied South American trade, and the main objective was served by bringing Turkey into the war and drawing great strength from the main theatre of operations, two battle cruisers to the Falklands, and indirectly numerous battle cruisers, battleships and men to the Dardanelles.

TACTICS IN THE BATTLE OF THE FALKLANDS

British

In general, the British conformed to the principles of war and applied them correctly in this battle, but the employment of the 26-knot *Bristol* in chasing transports instead of running down the *Gneisenau*, may be classed as a violation of the principle of the economy of force. The *Bristol* was superior in gun power as well as speed. The 23-knot *Carnarvon* served no useful purpose in the battle and should have been able to handle the transports as well as the *Bristol* did.

The destruction of the *Dresden* was of more importance than the destruction of the transports, so that this disposition may also be said to have been a violation of the principle of the objective.

There were eight British ships to five Germans. All of the British ships were superior in gun power to the *Dresden* and four of them were superior in speed. The British battle cruisers were greatly superior in speed and gun power. Protection was probably no better, if as good, as that of the Germans. It is worthy of note that not one of the German ships blew up. All were sunk by gun fire. They were short of ammunition, which may account for the fact. However, it was noticeable throughout the war that British ships blew up under gun fire whereas the German ships seldom did, indicating a better system of protection.

The British with superior speed maneuvered to hold the enemy at long range, an application of the principle of movement. The employment of the two battle cruisers and one armored cruiser to attack two armored cruisers is an example of the principle of mass.

The German gunnery was as skilful, if not more so, than the British, but owing to the long range, smaller and fewer guns, and lack of ammunition, was not as effective.

That it took five hours of gun fire to sink the two ships under the conditions that existed, indicates that the British gunnery was not what it should have been.

Admiral Fisher in his *Memories* (Page 136), referring to the Battle of the Falklands, makes the following remarks as to the unfortunate circumstances which would have resulted from a German victory:

"1. We should have had no munitions—our nitrate came from Chili.

"2. We should have lost the Pacific—the Falklands would have been another Heligoland and a submarine base.

"3. Von Spee had German reservists, picked up on the Pacific Coast, on board, to man the fortifications to be erected on the Falkland Islands.

"4. He would have proceeded to the Cape of Good Hope and massacred our Squadron there, as he had massacred Craddock and his Squadrons.

"5. General Botha and his fleet of transports proceeding to the conquest of German South-West Africa would have been destroyed.

"6. Africa under Hertzog would have become German.

"7. Von Spee, distributing his Squadron on every Ocean, would have exterminated British Trade."

German

In this battle the Germans violated the principle of security in failing to reconnoiter the position before disclosing the location and strength of their force. It would have been a simpler matter to have sent in an auxiliary or a prize to obtain information. He who attempts to surprise without information is apt to get surprised himself.

Their conduct of the battle was all that could be expected. Skill could not overcome the odds against them, and chance did not.

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The Determination of Azimuth by Means of the Binaural Sense

By Captain Richard B. Webb, C. A. C.

1. The determination of the azimuth of a ship, from the sounds caused by the motion of the propeller in the water, depends on a peculiar sense possessed by man known as the binaural sense. It is well known that a man standing in the open, where he is not bothered by echoes is able, upon hearing a prolonged sound such as the blast of a whistle or the ringing of a bell, to tell the direction from which the sound comes. Furthermore he will instinctively turn his head so as to face in the direction of the sound. This is largely accounted for by the fact that the human ears are separated by about 5½ inches and hence any sound, unless originating on the perpendicular line bisecting the line joining the two ears, will arrive at one ear before it does at the other. The human ear is sufficiently sensitive to detect this time difference and the listener's binaural sense tells him that the sound originated on the side of the ear which the sound first reaches. It is to make the sounds arrive at both ears at the same time (and thus eliminate the time difference) that the head is instinctively turned until the sound is faced. At this point the listener's binaural sense tells him that the sound is straight ahead. A sound originating directly behind the listener would, of course, also arrive at both ears simultaneously but the shape of the ear is such that such a sound would be less intense than if faced, so that no ambiguity results. The ability to determine the direction from which a sound appears to come (because of the time difference in the arrival of the sound at the two ears) is known as the binaural sense. The most definite sense of direction is obtained when the time difference is eliminated and the sound appears to be straight ahead *and all binaural direction finding depends on this fact.*

2. The binaural sense is possessed by all persons with normal ears. It is however more highly developed in some persons than in others. It is for this reason that not everyone can be developed into a competent listener for sound ranging work. The accuracy required for the binaural tracking of a ship is such that only persons having an extremely well developed binaural sense can do the work.

3. The time difference in arrival of sound which can be detected by the human ear is limited, being about 10 micro-seconds in a trained listener. For time differences less than this amount the sound appears

to arrive at both ears simultaneously and appears to come from directly ahead of the listener. On a baseline of the length of that separating the human ears (about 5½ inches) a time difference of this amount corresponds to a comparatively large angular displacement of the sound source, being about 1 degree if the sound is transmitted in air and about 5 degrees if the sound is transmitted in water. There is therefore a comparatively large angle through which an individual might turn his head and still get the impression of the sound reaching both ears simultaneously. In any of these positions the individual's binaural sense would tell him that the sound was straight ahead. For accurate location of the direction of the sound source, particularly in water, some means must be devised for decreasing the angular displacement corresponding to the smallest time difference which the human ear is capable of detecting. The smaller this angular displacement can be made the more accurate will be the location of the direction of the sound.

4. In sub-aqueous sound ranging this is accomplished by locating two hydrophones at the ends of a baseline very long in comparison with that of the human ear. These hydrophones pick up the sound in a manner similar to a telephone transmitter. They are connected to shore by a cable which terminates in a pair of telephone receivers, one receiver being connected to each hydrophone. The cable is specially constructed and electrically balanced so that the time required for the sound to appear in the receivers after being picked up by the hydrophones is the same in both circuits. The sound therefore arrives at the receivers with the same time difference with which it arrived at the hydrophones, as long as there is nothing except the cable between the receivers and the hydrophones. Because of the greatly increased length of the baseline a fixed time difference now corresponds to a much smaller angular displacement. Therefore the angular displacement which the sound source might undergo and still give the impression of the sound reaching the listener's ears simultaneously is greatly reduced and the accuracy greatly increased. Baselines of lengths up to 105 feet have been used with success, the longer baselines giving more accurate results, as would be expected. Baselines 300 feet long and 600 feet long have also been tried but have not been successful for reasons not entirely understood. It was found difficult to obtain a sense of direction on a 300 foot station and so far it has been impossible to obtain any sense of direction from a 600 foot station. It is believed that a base line not greatly in excess of 150 feet is probably the practical limit.

5. A water station (consisting of 2 hydrophones located on the ends of a baseline) is said to be set on a sound source when the sounds from both hydrophones appear to reach the listener's ears simultaneously. The listener, because of his binaural sense, then receives the impression of the sound being straight ahead or behind him. Such a setting is called a binaural setting and will be referred to as such hereafter.

6. The most obvious method of obtaining a binaural setting would be to turn the water station until the water paths from the sound source to the two hydrophones were equal. The sound would then of course reach both hydrophones (and subsequently the listener's ears) simultaneously. However the mechanical difficulties of turning a large station planted in the water are such that some other means of obtaining a binaural setting must be devised. It will be recalled that the hydrophones are connected to shore by special cables, terminating in telephone receivers, these cables being so electrically balanced that the sound would reach the listener's ears with the same time difference that it had on arriving at the hydrophone, if nothing were inserted in either line. Now, if some device is inserted somewhere between the listener's ear and the hydrophone which first received the sound, which will retard the sound from that hydrophone by an amount equal to the time difference of arrival of the sound at the two hydrophones, the sound will then arrive at the listener's ears simultaneously and a binaural setting will result. Such a device is called a compensator.

7. Probably the simplest form of compensator is the acoustic type. This consists essentially of a metal air column at the ends of which are two receivers, similar to telephone receivers, connected electrically to the hydrophones of the water station. In this air column is a tight-fitting movable piston in each face of which are outlets leading to an ordinary stethoscope worn by the listener. This piston may be moved by means of a hand-wheel so as to vary the air paths from the receivers to the listener's ears, increasing one and decreasing the other or vice versa. The sound reaches the receivers with the same time difference with which it arrived at the hydrophones. In making a binaural setting the hand wheel of the compensator is turned so as to increase the length of the air path from the listener's ear to the receiver first receiving the sound (and similarly decrease the length of the air path from the listener's other ear to the other receiver.) This is continued until the difference between the times required for the sound to travel over the two air paths is equal and opposite to the time difference of arrival of the sounds at the hydrophones. The sound from the two hydrophones will then arrive at the listener's ears simultaneously and a binaural setting results. The movement of the piston actuates a pointer which moves with relation to a fixed scale, arbitrarily graduated in equal divisions. Equal movements of the piston always vary the difference between the lengths of the air paths, from the receivers to the listener's ears, by the same amount. Hence the reading of the scale is always directly proportional to this difference, and since the time required for a sound to travel a given distance is directly proportional to the distance (providing the velocity of sound remains constant) the scale reading is directly proportional to the *time* difference introduced by the compensator. This time difference, when a binaural setting is ob-

tained, is of course equal to the time difference of arrival of the sound at the hydrophones and the scale reading is directly proportional to this time difference.

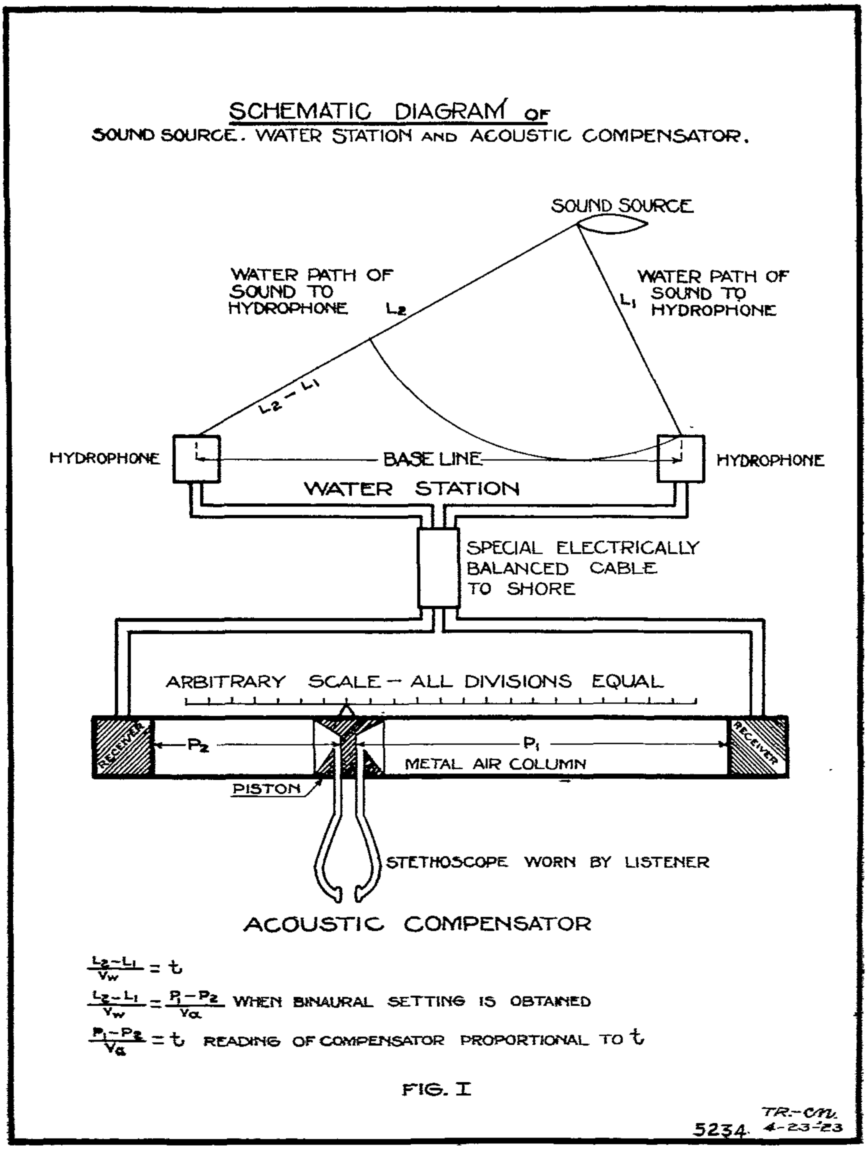


FIG. I

8. Figure I shows a schematic diagram of a sound source, water station and acoustic compensator. The sound waves travel out in concentric circles from the sound source and strike the hydrophones. The water path to the right hydrophone is L_1 and to the left hydrophone

is L_2. The difference in the lengths of the water paths (L_2-L_1) is the distance the sound must travel after striking the right hydrophone before it strikes the left one. This distance divided by the velocity of sound in water (V_w), (which is approximately constant for any given water temperature), gives the time difference (t) in the arrival of the sounds at the hydrophones, or $t=\frac{L_2-L_1}{V_w}$. The sound arrives at the receivers of the compensator with this same time difference (t). P_1 is the length of air path from the right receiver to the right outlet to the stethoscope and P_2 is the length of air path from the left receiver to the left outlet to the stethoscope. The two sides of the stethoscope have equal lengths of air paths so that the sounds arrive at the listener's ears with the same time difference with which they reached the stethoscope outlets. The difference in the lengths of the air paths is P_1-P_2 and this distance divided by the velocity of the sound in air (V_a), (which is approximately constant for any given air temperature), is the time difference or retardation introduced by the compensator. If the piston is moved until $\frac{P_1-P_2}{V_a}=t$ then the sound from the right receiver is retarded, in time, an amount equal to the time difference in arrival of the sounds at the hydrophones. The retardation is of course in the opposite direction so that the sounds arrive at the listener's ears simultaneously and a binaural setting results when $\frac{L_2-L_1}{V_w}=\frac{P_1-P_2}{V_a}$. As previously explained, the compensator reading is then directly proportional to the time difference of the arrival of the sounds at the hydrophone (t).

9. Another form of compensator which is more satisfactory, for reasons which will be discussed later, is the electric compensator. In principle this compensator is similar to the acoustic compensator except that the retardation of the sound from the hydrophone first receiving it is effected electrically by retarding the arrival at the receivers of the pulsating currents, generated by the action of the sound waves on the hydrophones. The electric compensator consists essentially of two electrical networks each consisting of small inductance coils in series, each coil being shunted by a condenser. These net works are introduced into the hydrophone circuits and terminate in a pair of telephone receivers worn by the listener, each receiver being connected to one hydrophone (through its own net work). These net works retard the arrival of the pulsating currents at the receivers and hence the arrival of the sound. The delay in the arrival of the sound at each receiver depends upon the number of sections which are in the net work of that receiver (each section consisting of an inductance coil shunted by a condenser). For small values of inductance and capacity per section

such as are used in these net works the retardation per section is very nearly constant for all frequencies between the ranges within which the sounds from boat propellers fall and is very nearly equal to $\sqrt{LC}$

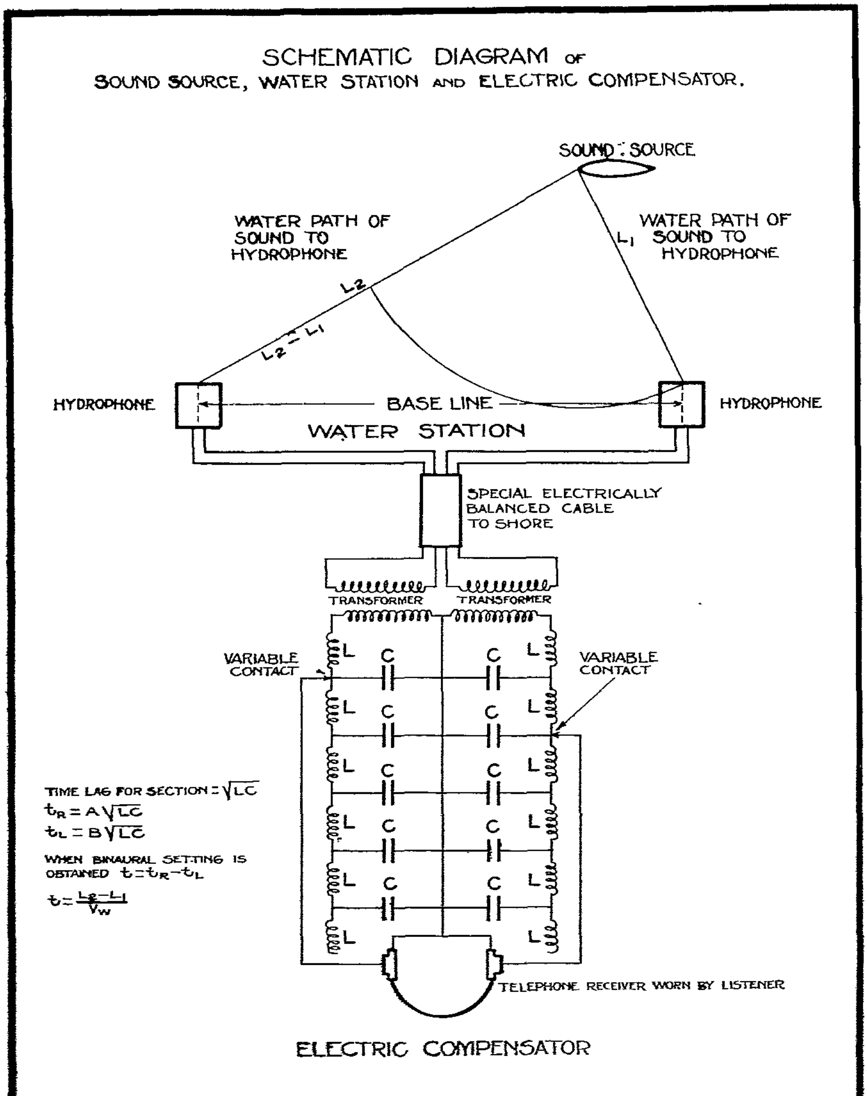


FIG. II

(For a discussion of the electrical principles involved and proof of these statements the reader is referred to "Electric Oscillations and Electric Waves" by Pierce, Chapter 16, pages 309 and 320 to 323.) By means of a switch actuated by turning a handwheel the number of sections in each net work may be varied so as to make the difference between the retardations of the sound from each hydrophone equal and opposite to the time difference of arrival of the sound at the hydrophones. The sound then reaches the listener's ears simultaneously and a binaural setting results. The hand wheel carries a scale arbitrarily graduated in equal divisions. The time retardation in all sections of the net work is equal (very nearly) and equal movements of the hand wheel always cut in the same number of sections of the net work in one side of the line (or cut out the same number of sections of the net work in the other side of the line). Hence the compensator reading is directly proportional to the time difference introduced by the compensator. When a binaural setting is obtained this is equal to the time difference of arrival of the sounds at the hydrophones. In other words the scale reading of the electric compensator like that of the acoustic compensator is directly proportional to the time difference of the arrival of the sound at the hydrophones.

10. Figure II shows a schematic diagram of a sound source, water station, and compensator. As in Figure I the time difference of the arrival of the sound at the hydrophones (t) is equal to the difference of the lengths of the water paths to the right and left hydrophones (L_1 and L_2 respectively) divided by the velocity of sound in water V_w or $t = \frac{L_2 - L_1}{V_w}$. The sound from the right hydrophone is retarded in time by the compensator, an amount proportional to the number of sections in the net work in the circuit of that hydrophone. The time retardation per section being equal to $\sqrt{LC}$, $t_R = A\sqrt{LC}$ where t_R is the retardation of the sound from the right hydrophone and A is the number of sections in the right net work. Similarly $t_L = B\sqrt{LC}$ where t_L is the retardation of the sound from the left hydrophone and B is the number of sections in the left net work. If the compensator hand wheel is moved until $t_R - t_L = t$ then the sound from the right hydrophone is retarded in time an amount equal to the time difference of arrival of the sound at the hydrophones. This retardation is of course in the opposite direction and the sound therefore arrives at the listener's ears simultaneously, giving a binaural setting. As previously explained the compensator reading is then directly proportional to the time difference of arrival of the sound at the hydrophones.

11. In discussing the relation between the setting of the compensator and the azimuth of the sound source, reference will be made to Figure III. Consider a sound source, such as a propellor driven steamer, at a given angle α from the normal of the water station. By the normal of the water station is meant the perpendicular line bisecting the base-line of the water station. As previously stated the sound of the steamer's propellor will travel out in concentric circles and will strike the hydrophones H and H_1. The water paths from the sound source to the hydrophones

are the distances L and L_1. Their difference (L_1-L) is the distance the sound must travel after striking the right hydrophone H before it strikes the left hydrophone H_1. This distance divided by the velocity

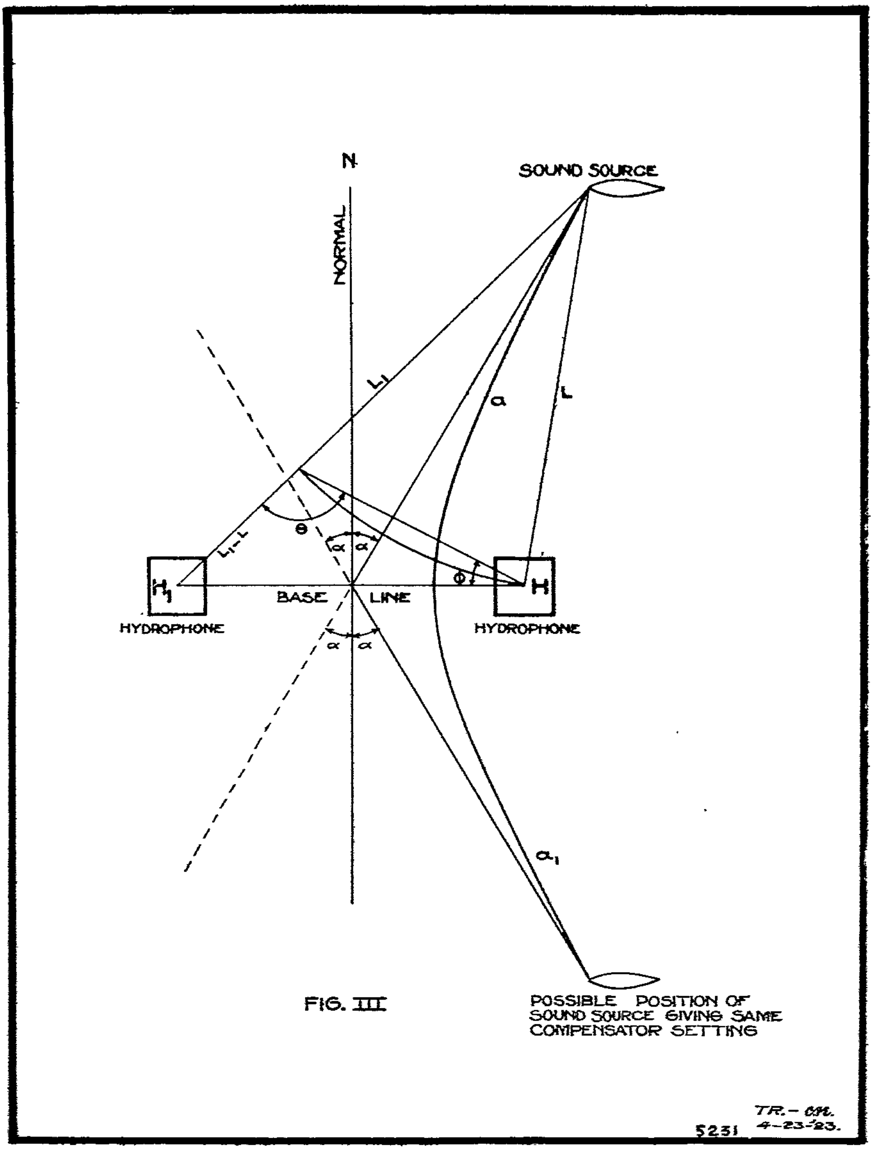


FIG. III

of sound in water V_w is the time difference of the arrival of the sounds at the hydrophones or $t=\frac{L_1-L}{V_w}$. As previously stated the compensator reading when a binaural setting is obtained is proportional to this time t.

Then as long as the velocity of sound in water remains constant the compensator reading when a binaural setting is obtained, is directly proportional to the difference of the water paths (L_1-L).

12. The sound source could then be at any point the difference of whose distances from the hydrophones was equal to L_1-L. The locus of all such points is a hyperbola, which is defined mathematically as the locus of all points, the difference between whose distances from two points, called the foci, is constant. The compensator setting thus determines the sound source as being somewhere on the hyperbola of which the hydrophones are the foci and of which the constant difference between the distances of all points of the hyperbola from the foci, is equal to L_1-L. The right hand of the branch of this hyperbola is shown in Fig. III.

13. It will be recalled that a hyperbola consists of two symmetrical branches which approach straight lines called asymptotes as they go away from the origin, finally reaching the asymptotes at infinity. The setting of the compensator, in the case being considered, determines that the sound source, is on the right hand branch of the hyperbola, for had it been on the other, while the time difference of arrival of the sound at the hydrophones would have been the same, in *absolute* value, the sound would have reached the left *hydrophone* H_1 *first.* The compensation would then have had to be inserted in the circuit from that hydrophone to obtain a binaural setting instead of being inserted in the circuit from the right hydrophone and a compensator setting equal in amount but of *opposite sign* would have resulted. Thus no ambiguity as to which branch of the hyperbola the sound source is on can ever arise.

14. Having fixed the branch of the hyperbola on which the sound source is located a real ambiguity arises as to whether the sound source is in front or behind the water station. Usually the water station is so near the shore that the sound source can never be behind it. However, if there is a possibility of a ship getting between the water station and shore two additional hydrophones are added to the water station and are placed at the ends of a short auxiliary baseline (not shown in Figure III) at right angles to the main baseline, one hydrophone being in front of the main baseline and the other behind it. When a ship is first heard a binaural setting is obtained on the auxiliary base (the main compensator may be used for this by having appropriate switching facilities installed.) If the ship is behind the main baseline the sound will first reach the hydrophone of the auxiliary baseline which is behind the main baseline and vice versa. The sign of the compensator setting will show which hydrophone first received the sound as the compensation will have to be inserted in the circuit of that hydrophone to obtain a binaural setting. The ambiguity is thus cleared with one setting of the auxiliary baseline and tracking can be continued with the main baseline.

15. Having thus established the position of the sound source with reference to the main baseline the relation between the compensator setting and the angle of the sound source from the normal will be considered. As previously stated a hyperbola approaches a straight line as it goes away from the origin. At a distance of from five to six times the distance between the foci the hyperbola and asymptote are so nearly identical as to introduce no material error if a point on the hyperbola is considered to be on the asymptote. As the range from the water station to the sound source, in sound ranging work, is many times the length of the baseline this condition is always satisfied. For any compensator setting then the sound source may be considered to be on a straight line making some fixed angle α with the normal of the water station. If the range from the water station is great compared to the distance between the hydrophones, as is always the case, the angle Θ in Figure III is nearly a right angle. The angle φ is then nearly equal to α and may be considered equal without material error. The sine of the angle φ (and α) may then be considered equal to $\frac{L_1-L}{B}$ where B equals the length of the baseline of the water station or $\alpha=\sin^{-1}\frac{L_1-L}{B}$ (very nearly). L_1-L is directly proportional to the time difference of arrival of the sounds at the hydrophones being expressed by the equation $\frac{L_1-L}{V_W}=t$ where V_W is the velocity of sound in water (approximately constant for any given temperature.) The compensator reading when a binaural setting is obtained being directly proportional to t the sine of α is directly proportional to the compensator reading. Thus if the length of the baseline, the velocity of sound in water, and the time delay of each unit of the compensator are known, the angle α may be computed for any compensator setting as follows:

c = compensator setting (when a binaural balance is obtained)

t = time difference in seconds introduced by compensator with setting c which is the time difference of arrival of sound at the hydrophones

k = proportionality factor relating c and t

L_1-L = difference in length of water paths from sound source to hydrophones

V_W = velocity of sound in water in feet per second

B = distance between hydrophones in feet

$$t=Kc$$

$$L_1-L=t\,V_W$$

$$\sin\alpha=\frac{L_1-L}{B}$$

$$\alpha=\sin^{-1}\frac{L_1-L}{B}$$

$$= \sin^{-1} \frac{T\,V_w}{B} = \frac{K\,c\,V_w}{B}$$

For a given compensator and water station and a given water temperature K, V_w and B are constant, hence $\sin \alpha = K^1 c$ where K^1 = constant $\frac{K\,V_w}{B}$

16. It will be noted that considering the compensator setting without regard to sign each computed value of α corresponds to four possible directions of the sound source from the normal of the water stations. The angle from the normal of the water station is the same in *absolute value* in each case. Two of the four possible directions of the sound source are indicated on Figure III by full lines. The other two are 180° displaced from these and are indicated by the dotted lines. The azimuth of each of the four possible directions of the sound source is, of course, different. If the azimuth of the normal of the water station is known, the azimuth of each possible direction of the sound source is easily computed from the computed value of α and its relation to the normal of the water station. The azimuth of the normal of the water station is approximately determined by ordinary orientation methods when the station is planted and this value corrected later by sound calibration. The method of clearing the ambiguity as to the position of a sound source being tracked has been discussed in paragraphs 13 and 14.

17. To calibrate a compensator to read azimuth with a given water station two methods may be used. The angles, from the normal of the water station, corresponding to the different compensator settings may be computed, by means of the formulas given in par. 15 and the azimuth of the possible positions of the sound source may then be computed from the known azimuth of the water station. A curve is then plotted with compensator readings as ordinates and azimuth as abscissas. This is of course an ordinary sine wave since the compensator setting is proportional to the sine of the angle from normal. The second method is to track a ship binaurally and visually and to plot the azimuths received visually against the compensator readings received binaurally, readings being taken simultaneously and allowance being made for the difference in velocity of light and of sound in water. An average curve is then drawn through the points. This method must be used if any of the constants given in paragraph 15 are unknown. Both methods have been used and the curves check very closely. It would of course be possible to graduate a compensator to read azimuth directly but there are serious objections to so doing. First the compensator could then be only used with the particular water station for which it was graduated. Second a scale proportional to the sine of an angle is awkward to read as the divisions grow smaller as the angle increases and above 60° such a scale could not be read closely enough for the required ac-

curacy. Third the application of corrections which are later discussed would be somewhat complicated. It is therefore necessary to have a separate calibration curve for use with each combination of compensator and water station.

18. To determine the azimuth of a sound source it is necessary to obtain first a binaural setting on the sound source (clearing the ambiguity as to which side of the water station the sound source is on, if necessary, as described in paragraph 15) and then with this compensator reading as an argument to go to the proper calibration curve and take off the azimuth. This method is cumbersome and not suited for rapid work. Under war conditions some more rapid method would probably have to be devised, but the present method is adequate for the present state of development of the system.

19. In all of the previous discussions it has been assumed that the velocity of sound in water remained constant. In actual practice the velocity of sound is found to vary with the temperature of the water and this gives rise to a condition which must be corrected for. The case of the electric compensator will be first considered.

20. Consider a sound source at a given angle α from the normal of the water station (Figure III). The difference between the lengths of the water paths (L_1-L) from the sound source to the hydrophones will always be the same for a sound source at this angle from normal. The time difference of arrival of the sounds at the hydrophones however will vary inversely as the velocity of the sound in the water (V_w) or $t = \frac{L_1-L}{V_w}$. It will be recalled that the compensator setting is proportional to this time difference t. Therefore, if the velocity of the sound in water is different from that on which the calibration curve was based, the correct azimuth of the sound source will not correspond, on the calibration curve, to the compensator setting obtained and a correction will have to be applied to the compensator reading before going to the calibration curve.

21. The derivation of the formula giving the correction in terms of the compensator setting obtained is as follows:

If the velocity of sound in water on which the calibration curve is based $= V$ the time difference of arrival of the sound at the hydrophones T is given by equation $T = \frac{L_1-L}{V}$. Now assume that the velocity is increased by an amount ΔV such that $V_1 = V + \Delta V$. The time difference is now given by equation $T^1 = \frac{L_1-L}{V_1}$ and T is greater than T^1 since V_1 is greater than V. The correction in seconds is then $T-T^1 = \frac{L_1-L}{V} - \frac{L_1-L}{V_1}$.

Substitute for $L_1 - L$ its equivalent $V_1\ T^1$. Then $T - T^1 = \frac{V_1\ T^1}{V} - \frac{V_1\ T^1}{V^1}$ or $T - T^1 = \frac{V_1\ T^1}{V} - T^1$.

Since the compensator settings are directly proportional to T and T^1 we can substitute these settings (C and C_1) in the above expression.

Thus $C - C_1 = \frac{V_1\ C_1}{V} - C_1$

and

$$C - C_1 = \frac{V_1\ C_1 - V\ C_1}{V} = \frac{C_1\ (V_1 - V)}{V}$$

where C = compensator setting (corresponding to velocity V) for angle α
C_1 = compensator setting (corresponding to velocity V_1) for angle α
$C - C_1$ = correction in terms of compensator units,
V = velocity of sound in water on which the calibration curve was based,
V_1 = velocity of sound at the moment.

22. In practice a curve is plotted giving the values of $C - C_1$ as ordinates and compensator settings as abscissas for a change in velocity of sound of 5 yards. The value of the velocity of sound in water corresponding to the mean water temperature to be expected is used for V in computing the data for this curve (and V+5 is used for V_1). As shown by the correction equation this is a straight line. For changes other than 5 yards, the correction as taken from the curve is multiplied by the fraction, $\frac{\text{Actual change in velocity}}{5}$. This may be easily computed by the use of a slide rule. The error introduced by using mean values of V and V_1 instead of the correct ones are negligible. Whether to add or subtract the correction is determined by knowing whether the velocity of the moment is greater or less than the velocity on which the calibration curve was based. If greater the compensator reading is too small, since it is directly proportional to t, and the correction is added. If smaller the compensator reading is too great and the correction is subtracted.

23. The velocity of the moment is determined by measuring the temperatures of the water and taking the corresponding velocity of sound from a "temperature—velocity of sound in water" curve. The relation between the velocity of sound in water and temperature is almost a straight line relation, the velocity increasing by about 1.7 yards per degree Fahrenheit.

24. As the time lag introduced by the electric compensator is independent of any temperature change the correction for the change in velocity of the sound in water is the only temperature correction required for courses run on the electric compensator. In the case of the acoustic compensator however a correction for the change in the velocity of sound in the air in the compensator is required in addition to the

correction for change of velocity of sound in water. This will be readily understood by reference to Figure I, remembering that the sound after leaving each receiver must travel over an air path before reaching the listener's ear. The retardation will $= \frac{P_1 - P_2}{V_a}$ which will evidently vary with V_a.

25. The derivation of the correction formula for the change in velocity in air is the same as for the derivation of the water formula, and the formula is identical, V and V_1 in the former case of course being the velocity of sound in air and C and C_1 being the compensator settings corresponding to the same angle from normal at these velocities. The method of making the corrections is identical, the same two curves (correction vs compensator setting for change in velocity of 5 yards and temperature vs velocity of sound in air) being required. It is immaterial whether the air or water correction is first applied. The relation between the velocity of sound in air and temperature is almost a straight line relation, the velocity of sound in air increasing by about 0.33 yards per degree Fahrenheit.

26. The following table shows approximately the azimuth errors which will result from neglecting a temperature change of only 6 degrees Fahrenheit at different angles of the sound source from the normal of the water station. This table is given for both air and water and the results were obtained from the ordinary calibration and correction curves previously described. It will be noted that the errors for air and for water are very nearly equal although the change in the velocity of sound in water is about 5 times as great as in air, for the same temperature change. This is explained by reference to the correction formula previously given $C - C_1 = \frac{(V_1 - V)}{V}$. It will be noted that the velocity of sound V appears in the denominator. The velocity of sound in water is about 5 times that in air so that although the numerator is different for air and water the denominator changes in about the same ratio and the correction remains about the same.

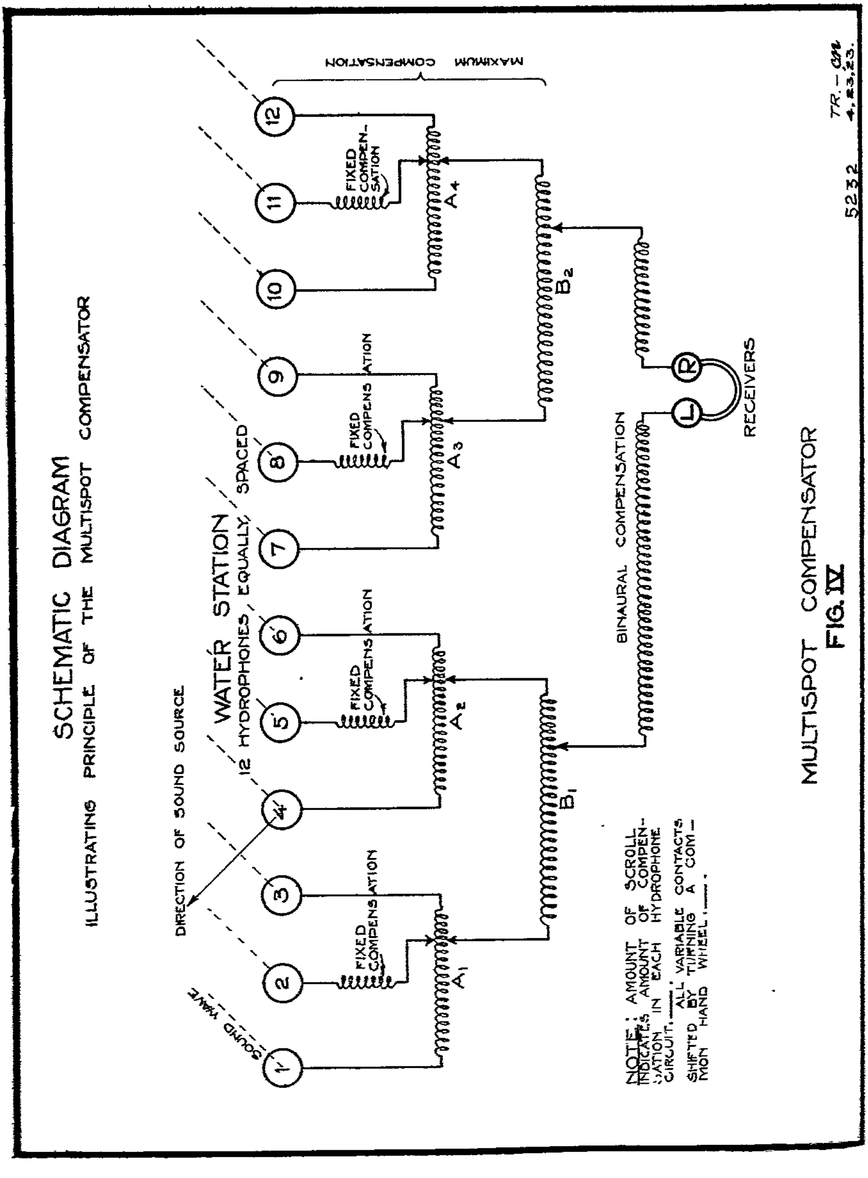
Azimuth Error Caused by Neglecting a Temperature Change of 6° Fahrenheit

Angle from normal	*Water* Change in velocity = 10 yards (approx.) Azimuth error degrees	*Air* Changes in velocity = 2 yards (approx.) Azimuth error
0	0	0
10	.09°	.06°
20	.14°	.12°
30	.20°	.18°
40	.28°	.24°

27. The characteristic of the acoustic compensator whereby two velocity of sound corrections are required is a most serious defect. There is no simple means of combining these corrections since in general the water and air temperature will vary independently, and the change in velocity per degree Fahrenheit is different in both cases. This defect and several minor ones, most of which are mechanical, has led to the virtual abandonment of the use of the acoustic compensator except for laboratory purposes.

28. Corrections for the velocity of sound in water, in the case of the electric compensator, and in addition corrections for the velocity of sound in air in the case of the acoustic compensator are the only corrections which the present accuracy of the system now justifies. At least one additional correction for the movement of the water due to currents and particularly tide will be necessary to obtain an accuracy of much less than 0.05°, but such corrections can be neglected in the present state of development.

29. The binaural units (consisting of the water station and the compensator) so far discussed have been of the simplest type. These units are known as two-spot units from the fact that the water stations consist of two hydrophones only. A unit which is more satisfactory for reasons which will soon be apparent is the so called twelve-spot unit. The water station used with this unit, as the name implies, has twelve hydrophones. These hydrophones are equally spaced and the right six are connected, through the compensator, to the listener's right receiver; the left six being similarly connected to the listener's left receiver. The compensator used is an electric compensator similar in principle to the two-spot compensator previously described, but considerably more complicated. Proper compensation is put into the circuits from the various hydrophones by turning a common hand wheel on the compensator. When a binaural setting is obtained on a sound source, the sounds from the hydrophones reach the listener's ears not only simultaneously but *in phase.* The sound heard in each ear is thus the sum of the sounds from six individual hydrophones and is a maximum. For any other setting of the compensator the sounds arrive at the listener's ears *out of phase* and partial cancellation of sound results. The result is that as a binaural setting is approached the sound intensity increases as the sounds from the various hydrophones come nearer into phase, reaches a maximum when the binaural setting is obtained, and falls off as the binaural setting is passed and the sounds once more get out of phase. The listener thus has not only his binaural sense to guide him in making a setting, but also the sense of maximum sound intensity. Greater accuracy thus results and the selectivity when two or more sources are present is far superior to that of the two-spot installation, since the sound being set on will always have the greater sound intensity due to the maximum effect just described.



MULTISPOT COMPENSATOR
FIG. IV

30. Figure IV shows a schematic diagram illustrating the principle of the twelve-spot compensator. For simplicity only one conductor, in each of the various circuits is shown. The dotted lines indicate the sound waves given off by a sound source to the left of the water station (in the direction of the arrow). These are of course concentric circles but if the sound source is at a distance short arcs of these circles are practically straight lines. The sound waves will evidently successfully reach the left hydrophone first and will reach the next hydrophone with a definite time difference and so on to the last one. Since the hydrophones are equally spaced the time differences are all equal. The hydrophones are connected to the compensator in groups of three through electrically balanced cable. The center hydrophone of each group has a network of a fixed retardation in its circuit. The networks in the other hydrophone circuits are variable. In making a binaural setting the compensator hand wheel is turned until the networks in the circuits of the right and left hydrophones of each group have the proper retardation to bring the pulsating currents (generated by the action of the sound waves on the hydrophones) from the hydrophones of each group simultaneously and in phase to the points A_1, A_2, A_3 and A_4. The same turning of the compensator hand wheel varies the net works which are in the circuits of the two right and two left groups until their retardations are of the correct values to bring the pulsating currents from the points A^1 and A^2 simultaneously and in phase to the point B_1 and the current from A^3 and A^4 simultaneously and in phase to the point B_2. Since the currents are brought into phase at points A_1, A_2, A_3 and A_4 and the points B_1 and B_2 the current at point B_1 is the sum of the currents from the left six hydrophones and the current at B_1 is the sum of the currents from the right six hydrophones and each is therefore a maximum. The same turning of the compensator hand wheel varies the networks in the circuits from points B_1 and B_2 so as to bring the currents from B_1 and B_2 to the receiver simultaneously and in phase. At the receivers the currents are converted into sound again and since the currents arrived simultaneously the sounds will also be heard simultaneously and a binaural setting will result. Since the currents arrived at the receivers in phase the sounds heard will be a maximum. It is evident from the foregoing that for any setting of the compensator except a binaural setting the sounds from the various hydrophones will arrive at the receivers out of phase and a sound intensity less than the maximum will result due to the partial cancellation of sound.

31. The method of calibrating the twelve spot compensator and of making corrections for changes in the velocity of sound in water is identical with that of any other electric compensator.

32. A brief summary of the results which may be expected from binaural azimuth determination as judged by the results obtained within the last few months may be of interest. The probable error in

binaural azimuth determination will be from 0.30° to 0.40° under ordinary conditions. It may be considerably less under favorable conditions. Ordinary "Long Island Sound" shipping may be tracked to 7 or 8 thousand yards under ordinary conditions and probably further under favorable conditions. With two boats in the field of a water station not closer than 3 to 4° it will probably be possible to track either at will with the 12 spot installation. In judging the foregoing it must be remembered that binaural azimuth determination is by no means the equal of visual azimuth determination and is in no way intended to supersede it. Its purpose is to act as an auxiliary to the visual system for which purpose it should be very valuable at night, in fog and under any other conditions where for any reason visual azimuth determination might be impossible.

33. In conclusion I wish to acknowledge my indebtedness to the officers formerly engaged in sub-aqueous sound ranging work whose notes were of extreme value in the preparation of this article. I am also indebted to various civilian physicists engaged in this work, for information obtained from informal conferences with them as well as from their various notes and articles. I am especially indebted to Master Sergeant Charles Nydam, C. A. C., who made the tracings from which the illustrations were made.

IN THE LAST ANALYSIS—

DEPENDABLE DELIVERY OF MAXIMUM STRIKING ENERGY

AT THE RIGHT PLACE AND THE RIGHT TIME—

THE MISSION OF COAST ARTILLERY

The Present Status of Sub-Aqueous Sound Ranging

By Major Harvey C. Allen, C. A. C.

Editor's Note: This memorandum, with the comment thereon by Colonel R. S. Abernethy, C. A. C., should serve to show the progress made to date by the Sub-Aqueous Sound Ranging Section, Coast Artillery Corps. This paper and the preceding article in this issue, by Captain Webb, have been especially prepared for the JOURNAL, through the cooperation of Colonel Abernethy and with the approval of the Chief of Coast Artillery, in order that Coast Artillery officers generally, may become advised of the technical principles and present status of the sub-aqueous sound ranging development. It is perhaps superfluous to suggest that the officer who has not had the previous opportunity of contact with this work would do well to precede the examination of the following paper by a careful reading of Captain Webb's article.

1. This memorandum shows conservatively (it is believed) the present status of the binaural phase of sub-aqueous sound ranging; it includes a brief description of existing equipment, a summary of past and recent experiments, an outline of possible future work and a statement of essential requirements.

2. The data on which this report is based were obtained by the zeal, initiative and energy of the various officers and enlisted men associated with the S. A. S. R. development work during the last three years and to them the Section is deeply indebted. The Section has also been aided a great deal by the personnel of the Navy Department, of the Bureau of Standards, and of other Departments of the Government as well as by various civilian concerns and civilian engineers and physicists who have taken a keen interest in the work.

PERSONNEL

3. The S. A. S. R. development work is being carried on by a special Section organized for this purpose during the latter part of 1921. The Section now consists of four Coast Artillery Officers, one Signal Corps Officer, five Enlisted Specialists, and one Coast Artillery Mine Company of about 70 men.

4. The organization of the Section and the distribution of personnel are as follows:

Executive Officer—Commands the Section and coordinates and supervises the work of the five sub-divisions.

(a) Administration, Planning and Supply Division: Consisting of one Signal Corps Officer, one Enlisted Specialist and about 5 enlisted men.

(b) Binaural, Radio and Orientation Division: Consisting of one Officer, one Enlisted Specialist and about 20 enlisted men.
(c) Laboratory Division: Consisting of one Officer, (not available at present), one Enlisted Specialist, and about 10 enlisted men.
(d) Construction Division: Consisting of one Officer, two Enlisted Specialists, and about 20 enlisted men.
(e) Company Division: Consisting of about 15 enlisted men. The officer-in-charge of the construction division also commands the company and supervises its general instruction.

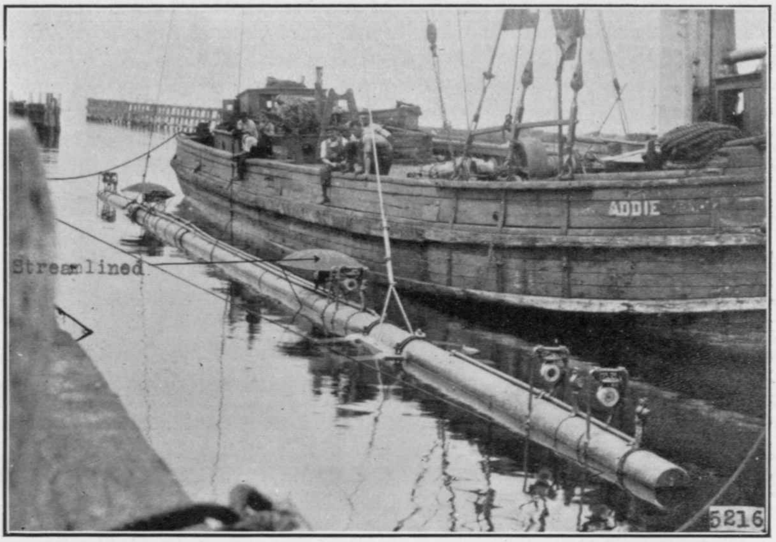


FIG. 1. K-3 STATION AS FIRST PLANTED. ALL HYDROPHONES EXCEPT W.E. 365-W WERE REMOVED WHEN STATION WAS REPAIRED

BINAURAL POSITION FINDING

PRESENT FACILITIES

5. The facilities now installed consist of seven water stations; five large, and a number of small compensators; the auxiliary shore station apparatus; a fairly well equipped laboratory, and well organized systems for visual position finding and radio telephone communication.

6. The characteristics of the various stations are indicated as follows:

Station K-3. A 110-ft. spar supported by two concrete blocks about 4-ft. high. There are two 50-ft. and two 100-ft. 2-spot binaural base-lines equipped with W.E. 365-W hydrophones mounted on the spar. The station was planted in November 1922 and is connected to shore apparatus at Fort Wright via Fort Michie by a 4-conductor T-tube cable; a selector mechanism mounted on the concrete supports permits ready selection of any of the four bases. This station was built by local personnel to take the place of K-1 station which had to be abandoned (see Figures 1 and 2).

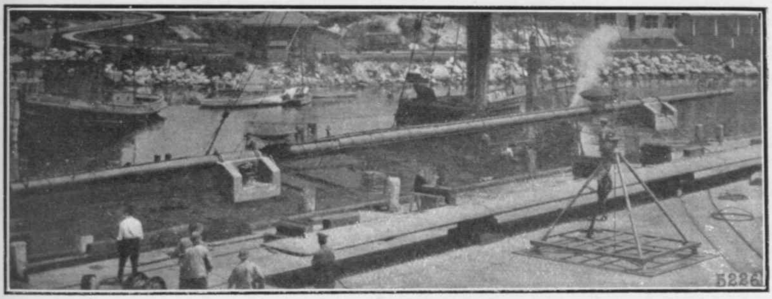


FIG. 2. STATION K-3

Station M-1. This station consists of two 1000 pound mine anchors each supporting a 3-ft. U bolt on which is mounted one W.E. 365-W hydrophone. The anchors were planted about 600 ft. apart on an east and west line, and the hydrophones are connected to the shore station at Fort Wright by one 4 conductor T-tube cable. The station was established to determine the binaural characteristics of a long base.

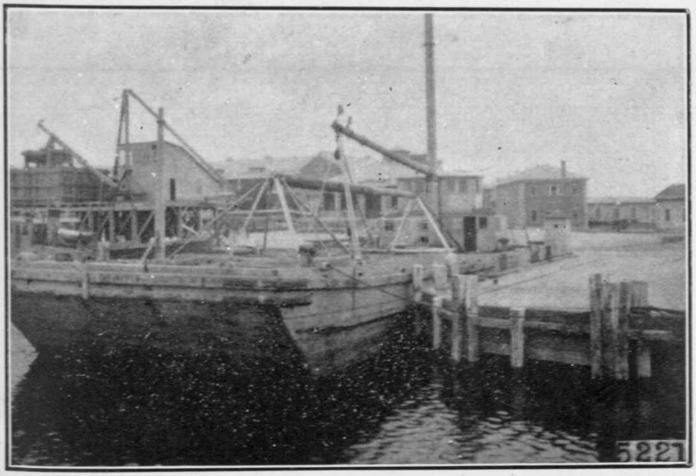


FIG. 3. STATION G-1

Station G-1. This is a 50-ft. 2-spot type of station consisting of two large structural steel tripods joined at their apices by a 50-ft. wooden spar. There were one pair of W.E. 365-W hydrophones and one pair of Submarine Signal Company rats mounted on the tripods about

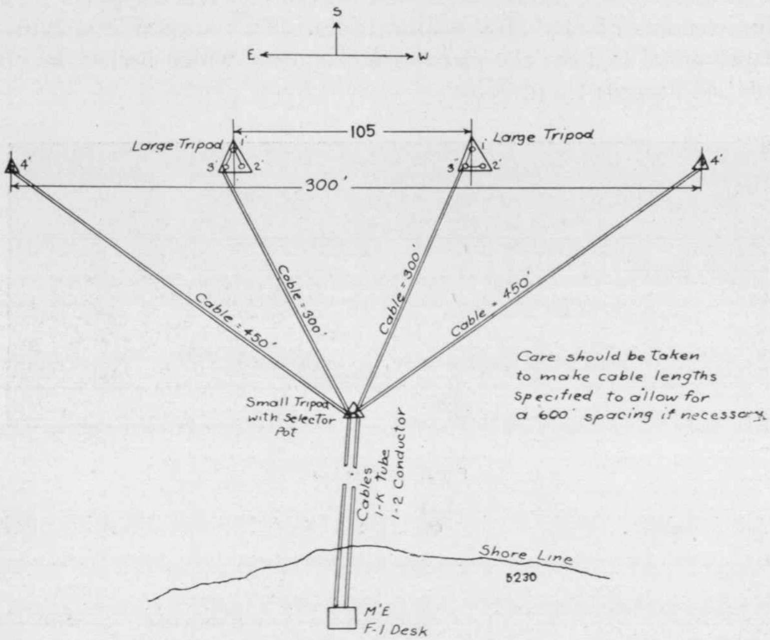


FIG. 4. STATION E-1

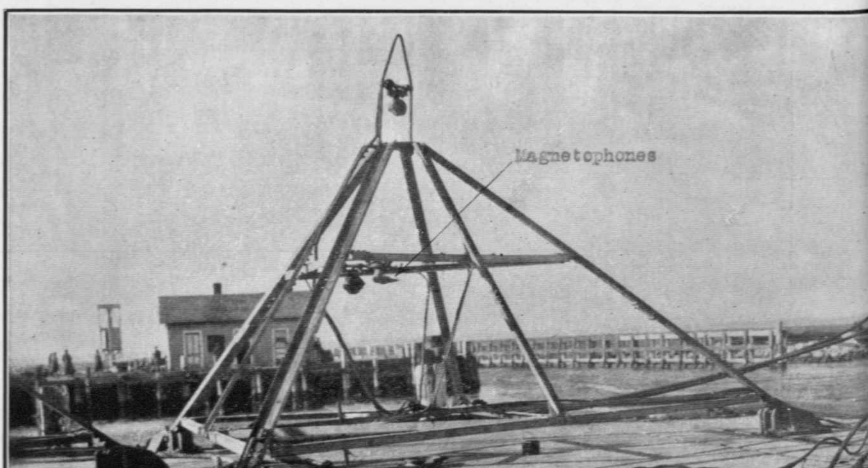


FIG. 5.

6 ft. from the bottom. The station was planted in July 1921 and connected to shore by two 4-conductor T-tube cables, one of which (pertaining to the S.S. rats) has since been picked up for other use. It is of interest to note that this station is still in first class working order although it has been down for over 18 months (see Figure 3.)

Station E-1. This station was planted in November 1922 and consists of two large tripods, two special concrete base structures, and one small tripod planted as shown in Figure 4. The large tripods mount

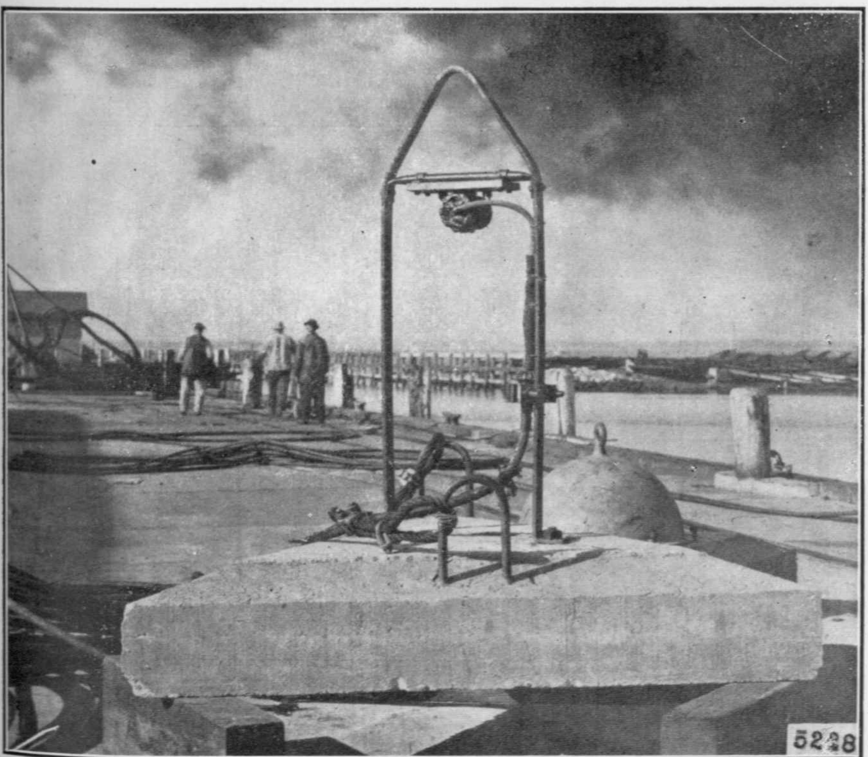


FIG. 6.

two pairs of W.E. 365-W receivers and one pair of magnetophones; the two concrete base stations mount one pair of large six button type of rats developed by Dr. H. C. Hayes (see Figures 5 and 6). This station is connected to shore station at Fort Wright by one 2 and one 4 conductor cable; selector mechanism mounted on the small tripod permits the ready selection of any of the four binaural base lines. The two-conductor cable was used for operating the selector mechanism to keep the switching currents off the listening circuits.

Station F-2. This station consists of a 110-ft. streamlined 15-in.

I-beam supported by two steel tripods which also mount 3 selector pots and the junction box, as shown in Figures 7 and 8. This is a multi-spot station mounting two sets of receivers, one set of 12 W.E. 365-W hydrophones and one set of 12 small Navy rats; the receivers in each

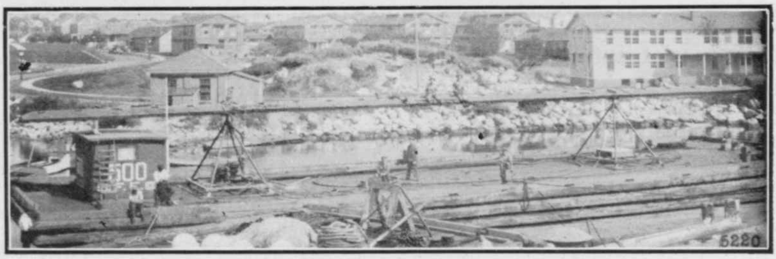


FIG. 7. STATION F-2

set being accurately spaced 9 ft. apart. The station is connected to shore by a 7-quad (28-conductor) electrically balanced cable designed and built especially for this installation. By means of selector mechanism mounted on the tripod and operated over the center quad of the

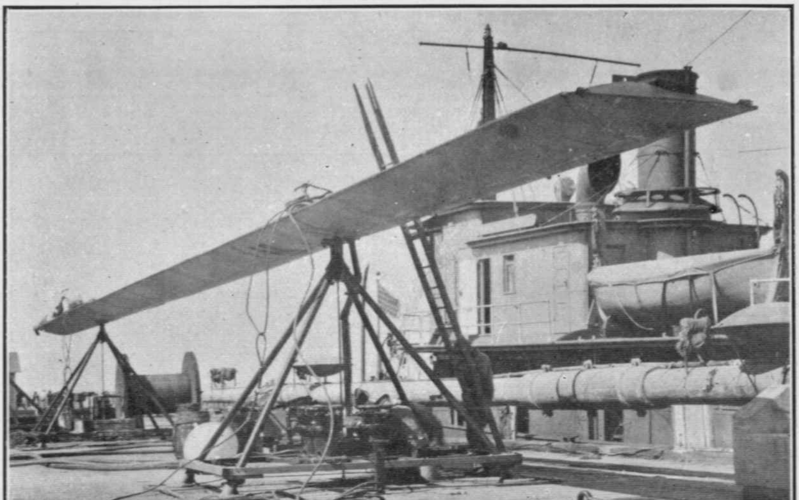


FIG. 8. STATION F-2

cable, either set of 12 receivers can be readily selected for listening. It is of interest to note that there are over 13 water tight joints in this installation none of which have shown any defects since the station was planted on September 16, 1922.

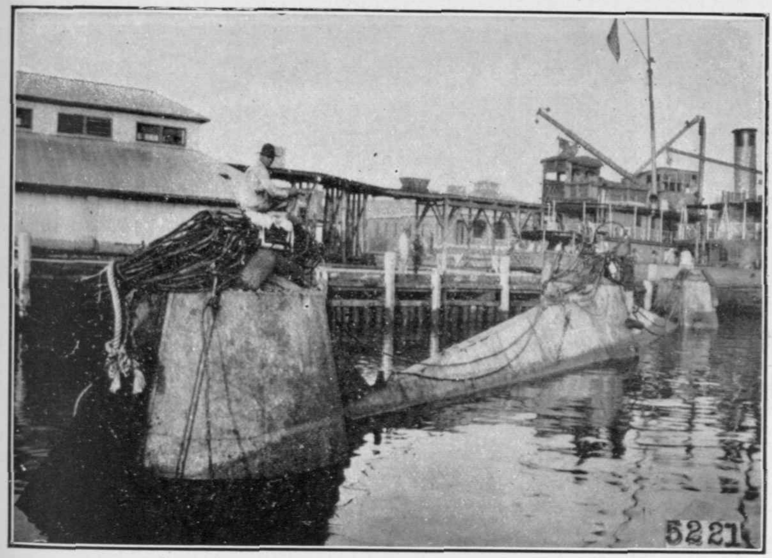


FIG. 9. STATION K-1

Station K-1. This station is a 90-ton 125-ft. caisson type of station provided with 5-ft., 50-ft., and 100-ft. 2-spot bases and was planted on September 15, 1921. It proved extremely difficult and expensive to handle and when electrical troubles developed the station was abandoned as being too expensive to raise and repair (see Figure 9.)

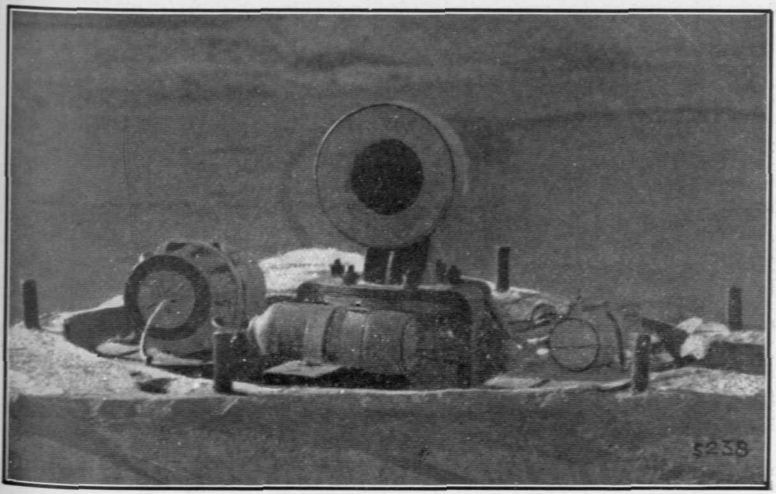


FIG. 10. STATION E-2, COVER REMOVED

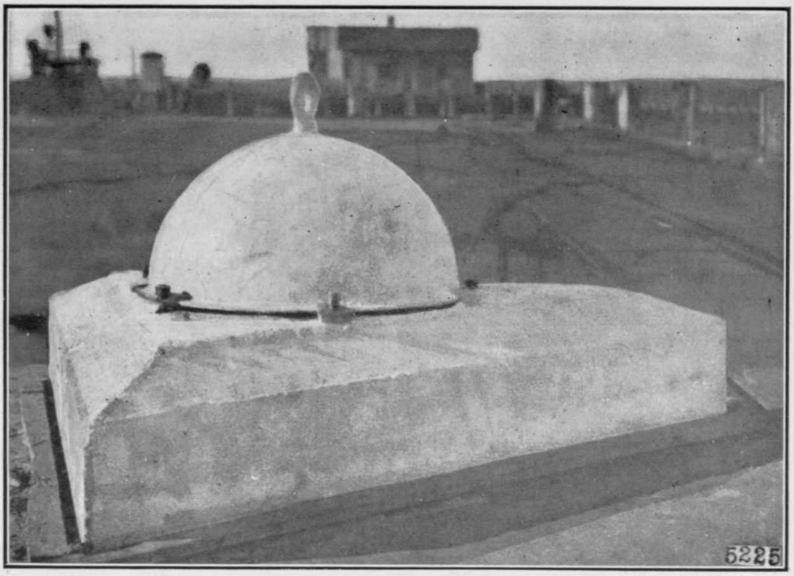


FIG. 11. STATION E-2, COVER IN PLACE

Station E-2. This station consists of four different types of hydrophones mounted on a concrete block and covered by one half of a 24-in. mine case (as shown in Figures 10 and 11.) The station was planted to determine the relative merits of a W.E. 365-W hydrophone, a small Navy rat, a Submarine Signal rat and a large 6-button type of Hayes rat.

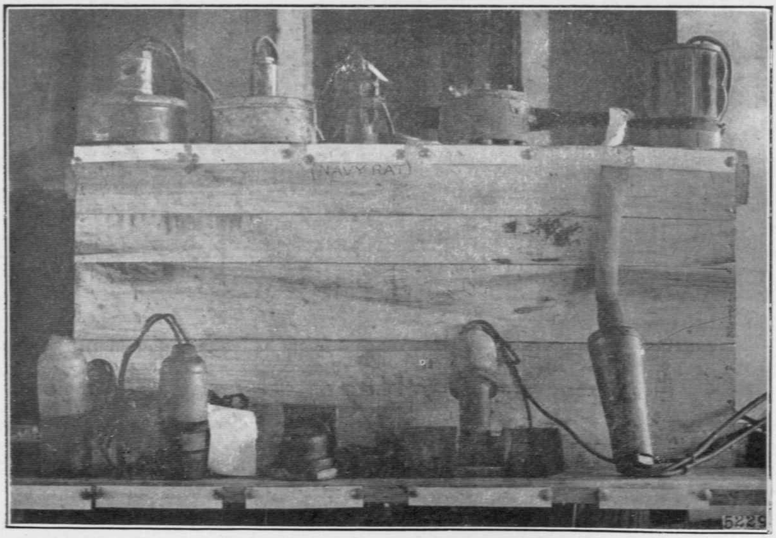


FIG. 12. TYPES OF SUBMARINE RECEIVERS

7. Some of the various types of submarine receivers developed during and since the War are illustrated by Figure 12. Of these the large and small Hayes rats, the magnetophones, the W.E. 365-W hydrophone, the G.E. and S.S. rats are the only types of interest. The other types are obsolete and of no value except from a historical standpoint.

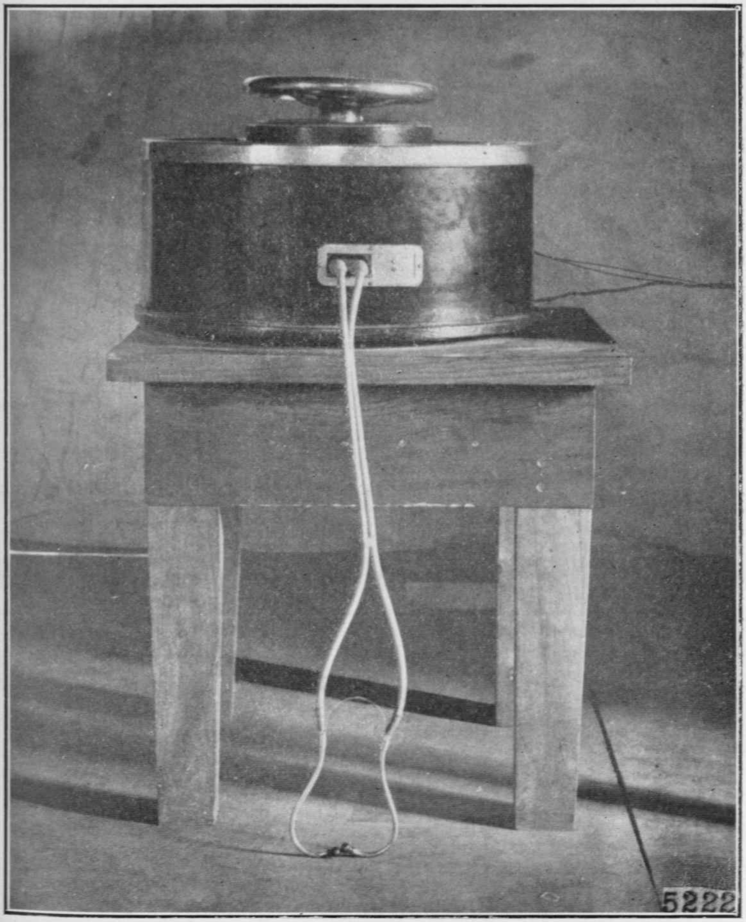


FIG. 13. G. E. 50 FT. 2-SPOT ACOUSTIC COMPENSATOR

8. The compensator equipment available for use with the water stations consists of one multi-spot and four 2-spot compensators, descriptions of which are given in the order of their delivery to this Section.

(a) One 50-ft. 2-spot acoustic compensator built by the General Electric Company for the Navy during the latter part of the World War, and turned over to the Coast Artillery when that branch of the service undertook the development of sub-aqueous position finding in

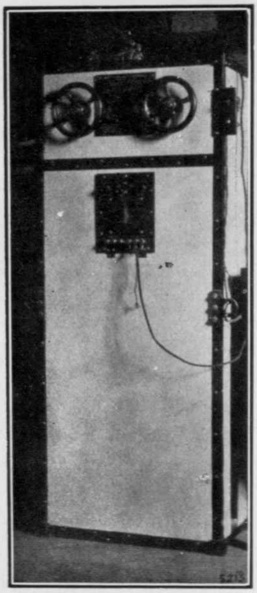


FIG. 14. 22 FT. 2-SPOT ELECTRIC COMPENSATOR

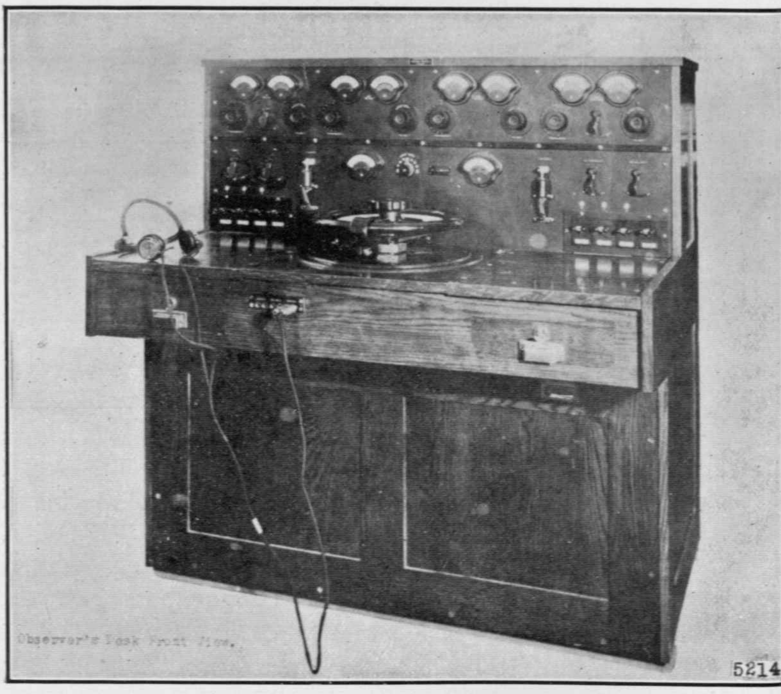


FIG. 15. W. E. 100 FT. 2-SPOT ELECTRIC COMPENSATOR

1919. This was the largest and probably the best two-spot compensator built prior to 1920. (See Figure 13.)

(b) One 22-ft. 2-spot electric compensator having a vernier reading to four micro-seconds. This compensator was built during 1920 and 1921 for laboratory use, according to specifications of Dr. G. W. Pierce of Harvard, and is very satisfactory for the purpose (see Figure 14.)

(c) One 100-ft. 2-spot electric compensator provided with two stages of binaural amplification and switching facilities to permit the selection, over a 4-conductor cable, of any one of eight 2-spot baselines. This compensator was the product of a development contract made

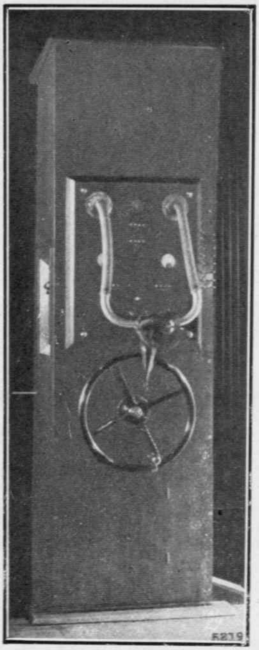


FIG. 16. SUB. SIG. CO. 100 FT. 2-SPOT ACOUSTIC COMPENSATOR

with the Western Electric Company in 1920, and has proven to be a very satisfactory type. It is by far the best 2-spot compensator ever developed and with slight modifications will, it is believed, be an entirely satisfactory type for standardization for 2-spot equipment (see Figure 15.)

(d) One 100-ft. 2-spot acoustic compensator built during 1921 and 1922 by the Submarine Signal Company along the lines of compensators developed in Germany. The compensator as it came from the factory did not prove a success and it is only since some changes have been made locally that any promising results have been obtained from it. Figure 16 shows the compensator as it was delivered. The changes made, which seemed to improve the compensator, consisted in replacing the heavy rubber ear tubes and ear pieces by brass fittings tapered to accommodate stethoscope tubes such as are shown on the 50-ft. acoustic compensator described in (a) above.

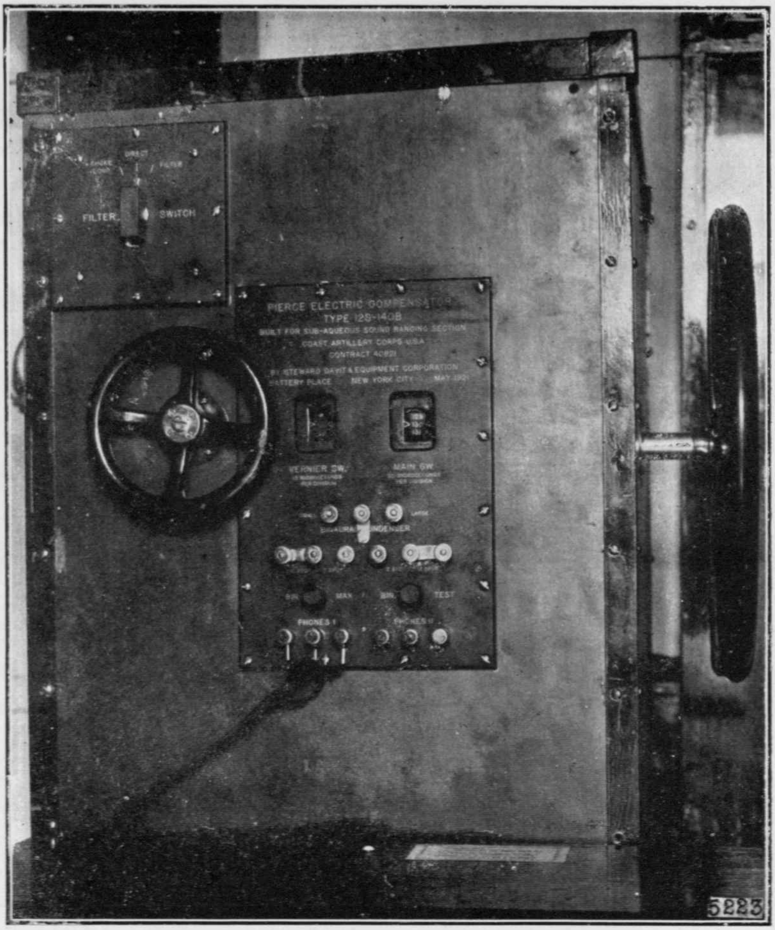


Fig. 17. Pierce Electric Compensator

(e) One 12-spot electric compensator built for use with the F-2 multi-spot water station. This compensator together with its water station F-2 are the products of development contracts placed with Dr. G. W. Pierce of Harvard University and the Steward Davit and Equipment Corporation of New York, during 1920. The compensator was designed by Dr. Pierce and built by Dr. Pierce and the General Radio Company of Cambridge, Massachusetts. It was delivered to this Section during 1921 and installed by local personnel during 1922.

The installation was designed to eliminate interference from other ships in the field and to increase the listening range by the maximum effect of the 12 hydrophones. Tests to date have indicated that the installation will be very satisfactory; however, the compensator switch has many mechanical defects and will probably have to be replaced by a better design (see Figures 17 and 18.)

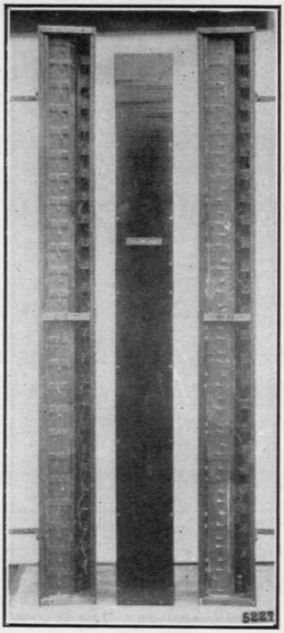


FIG. 18. TWO OF THE 24 TIME LAG COLUMNS OF THE PIERCE COMPENSATOR

9. The shore station apparatus and equipment includes, in addition to the compensators, rather an extensive storage battery plant for power for the various installations, a laboratory well equipped for making necessary tests, and switching arrangements to permit the use of any compensator on any water installation or any number of compensators in parallel on any one water installation. The switching arrangements were installed by local personnel during 1922 and have proven very useful.

10. Means for visual tracking of vessels to obtain data for comparison with that obtained by binaural installations are provided by complete position finding systems with baselines to cover the entire water area used. There are short baselines at Fort Wright and Fort Michie and two long baselines between the two forts. Much of the data for these baselines were accumulated by the S. A. S. R. Section but have proven of considerable value to the entire Coast Defenses.

11. The present equipment, which has required all of 1922 for installation, is considerably more extensive and better suited to carrying on the development work than that available on January 1st, 1922, which consisted of two 50-ft. 2-spot water stations, F-1 and G-1, and three compensators described under a, b, and c of par. 8. The G-1 station is described in par. 6, the F-1 station was of similar mechanical structure but equipped with a war-time type of hydrophone now obsolete. This station was planted in 110 feet of water in December, 1920, and connected to the shore station at Fort Wright by one 4-conductor cable; selector mechanism on the tripods permitted the selection of 8 ft. and 50 ft. binaural baselines. Unfortunately the station took such an unfavorable angle in planting that the useful field was extremely limited; this together with the fact that the station was very noisy and equipped with an obsolete type of receivers made it of little use and the station and its cable were picked up in 1922, the cable being used for the K-3 station.

Earlier Tests

12. The first binaural test work of any material importance started about November 1st, 1921, upon the completion of summer water work. During the 1921-1922 winter months such tests were run on F-1 and G-1 as weather and availability of boats permitted. Reports covering these tests were submitted early in 1922. The following is a brief summary of conclusions drawn from these tests.

(a) The G-1 station equipped with W.E. 365-W receivers was far superior to F-1 station equipped with the old type of seaphones.

(b) The G-1 station was affected less by water noises than F-1. This was believed to be due to the fact that F-1 was more exposed and the water was often very rough over the station.

(c) The 100-ft. 2-spot electric compensator provided with amplification was far superior for general use to the 50-ft. acoustic compensator. It was believed that with comparatively slight modifications the 100-ft. electric compensator would be an entirely satisfactory type for 2-spot installation.

(d) The 365-W hydrophones seemed to be far superior to any former type.

(e) On calm days with only one ship in the field it was ordinarily possible to track tug-boats, tramp steamers, etc., to a range of 5000 to 8000 yards and large 10,000 to 15,000 ton steamers to 15,000 or 20,000 yards. It was found to be much easier to track a vessel if it had a characteristic thump or squeak which predominated above the other disturbances.

(f) When it was rough and the sea in the vicinity of the wate station was covered with white caps the listening range was materially decreased; often in very rough weather being reduced to 2500 to 4000 yards for tugs, etc. There was little opportunity to obtain data on this point from large ships.

(g) A good listener under favorable circumstances with the boat making small angular changes during the 15 second observing interval could obtain azimuth bearings of a ship to within a probable error of about ½°, with extreme errors of from 1° to 3°. Choppy sea or a lack of a characteristic note in the ship's noises or interference from other boats in the field materially reduced this accuracy.

(h) The presence of two or more boats in the field made tracking by a 2-spot unit difficult and often impossible.

(i) Sound tracks of ships obtained under favorable conditions by F-1 with the 50-ft. acoustic compensator and G-1 with the 100-ft. electric compensator gave range errors of from 50 to 150 yards at ranges of 4 to 5 thousand yards. These tracks were difficult to obtain as the bad angle of F-1 makes the field common to F-1 and G-1 very small.

Program for 1922

13. (a) From the above data obtained from F-1 and G-1 installations the program for 1922 was made up. This contemplated the completion of the equipment now installed and previously described. The following objects were in mind:

(1) Elimination of trouble due to interference.
(2) Increase in accuracy.
(3) Within limits of available cable place the stations to cover the entire entrance to Long Island Sound and especially to cover the target practice area.

(b) It was believed the multi-spot unit would increase the accuracy and reduce interference, that the longer baselines would increase the accuracy and possibly reduce interference, and that a suitable arrangement of the water stations would cover the entire entrance to Long Island Sound.

Recent Tests

14. (a) Lack of boats since the installation was completed has prevented the making of necessary tests and entirely prevented the calibration or testing of the K-3 station; however by tracking commercial shipping, which unfortunately was at close range, it has been possible to calibrate and test at short ranges the multi-spot station F-2, one of the 105-ft. bases of E-1 and to run some tests on the other binaural baselines. It has also been possible to obtain a little data as to range of K-3 station.

(b) From data obtained from the rather incomplete tests made to date the following conclusions can be drawn:

(1) Previous data. The conclusions given in par. 12 above that were drawn from the first tests of F-1 and G-1 have been verified.

(2) Compensators. An electric compensator is believed to be much superior to an acoustic compensator and it is doubtful whether further development of the latter type is warranted.

(3) Interference. The multi-spot unit F-2 eliminates interference to a considerable extent and permits one boat to be tracked when other boats are in the field provided the angular displacement of the nearest boat is 5° to 10° and the boats' noises are of about equal intensity.

(4) Accuracy. For the average listener a multi-spot installation seems to give more accuracy under average conditions than a 2-spot installation.

(5) Carbon Button Detectors. Of the various types of submarine detectors now developed the W.E. 365-W seaphone and the small Navy rat seem to be the best for sensitivity, tone and quality. The development work on these types of detectors must be continued.

(6) Magnetophones. It is possible to track ships by use of magnetophones with two or more stages of amplification, and objectionable water noises seem to have less effect than with carbon button hydrophones; however the magnetophones are insensitive and seem to sound nearly the same for all types of boats, the latter defect being especially objectionable from a standpoint of selectivity.

(7) Length of Baseline. Good binaural tracking has been done on the 50-ft. and 100-ft. two-spot bases and the 100-ft. multi-spot base. It is believed any baseline not over 150-ft. in length will be entirely satisfactory. It has been possible to track a vessel by the 300 ft. base, but the binaural image was hard to find and did not seem as sharp as on shorter baselines. No results have been obtained from the 600-ft. baseline as it appears to be impossible to obtain a sense of direction from such a long base.

(8) Short Finding Baseline. When using baseline of 100 ft. or over it is very desirable to place a 50-ft. baseline at the center of the longer base to facilitate finding the approximate location of the ship. This is especially true if the compensator has not more compensation than the total length of the longest base with which it is to be used.

(9) Amount of Compensation. If practicable a compensator should have at least 2% more compensation than the longest baseline with which it is to be used and the retardation elements should be computed for the lowest velocity to be expected. This is of special importance in a multi-spot installation.

(10) Amplifiers. It has been clearly demonstrated that one or two stages of amplification such as are provided in the 100 ft. electric compensator are advantageous.

(11) Range. No very good data are available as to ranges of these installations as no boats for long range work have been available since the installations were completed.

(12) Two-spot versus multi-spot. It is believed that a multi-spot

installation is decidedly better than a two-spot installation. However as there are uses for both types and the two-spot is less expensive than the multi-spot, it is believed development work should be continued on both types, the multi-spot having priority if funds are limited.

(13) Sound Source. A number of types of sound sources for use as datum points have been tried, no satisfactory type was found. Two types are now under consideration.

(14) Quantity production. In case of national emergency data is available to place in quantity production a very serviceable two-spot binaural installation; however, it would be better to continue tests on the two-spot before standardizing this equipment. The multi-spot water station seems satisfactory, but the compensator switch needs radical changes before it would be available for quantity production.

General Program for 1923

15. Tests of existing installation.

(a) Run range and interference tests comparing multi-spot and two-spot installations.

(b) Calibrate and test K-3 station to have a complete binaural baseline to track vessels towing for target practice, and favorable commercial shipping.

(c) Obtain comparative data as to relative accuracy and interference qualitities of 50 ft., 100 ft., 300 ft. and 600 ft. two-spot bases.

(d) Experiment with amplification for multi-spot and other units using commercial amplifiers now available.

(e) Determine relative merits of various types of detectors now installed.

16. Laboratory tests.

(a) Determine extent to which lack of matching of two receivers broadens the binaural image.

(b) Conduct tests to determine relative still water merits of existing types of sound detectors and what modifications will give improvements.

(c) Develop and test directional types of receivers with a view of eliminating surface water noises.

(d) Conduct tests of long aerial binaural baselines to obtain data as to limiting lengths, etc.

(e) Develop better means for matching hydrophones, for intensity and phase, for multi-spot use.

(f) Conduct additional tests to obtain data on relations between temperature, specific gravity, and velocity of sound in sea water.

17. Installation and development of new apparatus.

(a) Buy and install a new multi-spot switch for present F-2 unit.

(b) Buy and install a special filter to determine its usefulness in eliminating water noises and objectionable interference.

(c) Build and install, if funds are available, a complete multi-spot unit at Fort Michie to provide a complete multi-spot position finding system.

(d) If funds are available build a 150-ft. 2-spot water station and so install it as to permit sub-aquesous position finding of commercial shipping.

(e) Install temperature recording apparatus to obtain hourly readings of the temperature of the water in Block Island Sound, as these data are essential to even reasonably accurate binaural tracking.

Difficulties and Prospects

18. There are four outstanding difficulties to be contended with which seriously reduce accuracy and range.

(a) Noises due to tide, currents and especially surface disturbances above the hydrophone stations.

(b) Lack of exact mechanical and electrical similarity of the hydrophones.

(c) Sputtering, burning, and grating noises inherent in any carbon button detector.

(d) Interference caused by noises from more than one ship in the field.

19. Of these difficulties (a) and (b) are the most serious and the hardest to overcome. If water noises could be eliminated or materially reduced and perfectly matched non-resonant hydrophones produced then sound ranging development work would be comparatively easy, for it has been clearly demonstrated that shore apparatus can be produced which will have the desired degree of accuracy and it is believed a multi-spot unit will, to a reasonable degree, solve the interference problem.

20. It is evident from the above that the key to increasing the range and accuracy of sound ranging apparatus lies in the development of hydrophone stations free from water noises and perfectly matched. Unfortunately there is nothing at present to indicate that such hydrophones can be developed and it is certain that their development, if possible, will require a long time and a great deal of discouraging development work. However there is apparently no alternative and the necessary experimental work must be continued.

21. In the present state of development (and there is nothing to indicate any *startling* improvement in the *immediate* future) it is believed the following are the average results obtainable with experienced personnel under favorable conditions:

(a) Tracking range. Under favorable conditions when sea is not very rough and interference is not bad, little difficulty should be experienced in tracking tugs, etc., to 5000 to 8000 yards and large ships to twice these ranges. If, however, there is a very choppy sea which breaks over the water station, or there is marked interference, this range will be materially reduced. It should be noted in this connection that a ship can be heard at ranges considerably beyond those at which binaural settings can be obtained.

(b) Accuracy of azimuth determinations. For two-spot 100 ft. installations under favorable weather conditions with only one boat in the field the average error will probably be between ¼ and ½ degree, with maximum errors of from 1 to 2°. For a multi-spot it will be possible to obtain this same degree of accuracy with two or three boats in the field if they have an angular displacement of 5 to 10° and are of about equal intensity.

(c) Errors in location by complete sound position finding system. Range errors in location will depend on the angular errors of the two observing stations and the angle of intersection at the target. They will probably vary between 50 and 500 yards.

(d) Comparison with visual. It is evident that sub-aqueous position finding is far from perfect and far from what is desired; however, even the inaccurate data available from S. A. S. R. installations are better than no data at all, which will often be a condition during periods of low visibility if only visual position finding systems are available.

DEVELOPMENT POLICY

22. It is believed to be essential that the following points be given consideration in analyzing results obtained from or determining any policy for sub-aqueous sound ranging development work:

(a) The apparatus and its development are expensive and its commercial application is limited.

(b) A small amount expended each year in development will accomplish more than large sums spent under the pressure of National emergency.

(c) Progress will often be slow and very discouraging.

(d) Development and test work should be concentrated at one place where necessary facilities are available. This place should be reasonably close to sources of commercial supply.

(e) Boat service is essential during the entire year, and one mine planter, one D.B. boat of the "L" type and one motor yawl of the "M-100" type are the minimum requirements. Lighter service can be hired cheaper than it can be maintained.

(f) Necessary elements of an installation must be individually developed before they can be combined to produce a practical system. For example sub-aqueous position finding is dependent on the further development of a station which will consistently give accurate azimuth to a useful range.

(g) The attainment of the desired degree of accuracy and other desirable characteristics may not be possible but it will usually require a great deal of work to establish the negative and for this reason funds expended on experiments that were a failure are often well spent.

(h) There are a great many important points about which no information is available and relative to which data can only be obtained by expensive experimental methods.

(i) Funds can be spent more usefully in developing new apparatus than duplicating existing equipment.

(j) Plans should be kept in hand for quantity production of the best possible apparatus should such action become necessary, but in the present state of progress, equipment should not be standardized and issued to the service as such apparatus may soon become obsolete. Funds that would be spent in service installations can better be spent on development work.

(k) A sub-aqueous position finding system is far from a perfect system, and its value lies an an *auxiliary* and not as a *substitute* for visual systems.

(l) Personnel should be assigned to the work who have reasonable qualifications and are interested. Research work cannot be carried on successfully by unqualified and uninterested personnel and temporary assignments to the work should be avoided. It requires at least a year for an officer or enlisted specialist to become really familiar with the work and in a position to aid materially in its development.

(m) The personnel engaged in this work, as outlined in par. 3 is the minimum that can efficiently carry on the development work.

(n) Qualified clerical personnel is essential as the value to be derived from years of experimental work depends on how well such data are tabulated and filed.

(o) Although sub-aqueous position finding at present is far from perfect and there is much to be desired and a great deal of necessary development work ahead, still it is believed, that satisfactory progress has been made since the Coast Artillery undertook the work, and that tests to date have clearly demonstrated that further development of this means of position finding is an essential feature of our preparations for National Defense.

Headquarters Coast Defenses of Long Island Sound (Sub-Aqueous Sound Ranging Section) Fort H. G. Wright, New York

REMARKS

1. Major Allen's statements seem conservative, almost to the extent of pessimism.

2. The binaural position finding system is poor when compared with visual position finding in clear daylight but the latter may be rated

00%. The binaural system as at present developed is incomparably etter than any other now under development.

3. Generally speaking the system promises to furnish position findıg data accurate enough to permit firing at one capital ship of a fleet ıoving at full speed at a range of upward of 10,000 yards from the nderwater installation.

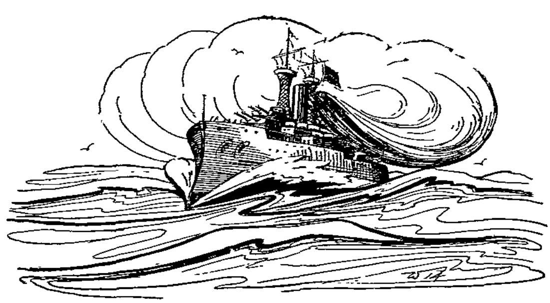
4. My general conclusions are—

(*a*) That binaural position finding is, and promises to remain, our best means of obtaining firing data when we can't see.

(*b*) That Sub-Aqueous Sound Ranging will be a necessary auxiliary to the defense of important harbors.

5. Major Allen and his assistants concur in these remarks.

(Sgd) R. S. Abernethy,
Colonel, Coast Artillery Corps.



The Importance of Coast Artillery in Our National Defense

By Major Robert R. Welshmer, C. A. C.

OUR national policy is essentially one of non-interference in the affairs of foreign nations and results in a military policy purely defensive in character. The popular slogan of more than a century ago "Millions for defense but not one cent for tribute," truly reflects our present day National Policy. A defensive national policy does not preclude the use of military power offensively in defense of our country. We most probably would act offensively, and this, at first instance, through our Navy.

The effective offensive power of our Navy depends to a large extent on effective coast defenses in the continental United States, Panama and our Insular Bases. Admiral Mahan has emphasized the importance of our coast defenses as offensive agencies since they facilitate offensive naval action, and this principle is recognized by both the War and Navy Departments. In so far as the Army is concerned, the main agencies in coast defense operations are the Air Service and the Coast Artillery. The Air Service in conjunction with the Coast Artillery increases the efficiency of our coast defenses, but in no sense may it be said that the Air Service limits the need for efficient coast defense armament, including antiaircraft artillery, and personnel. Today, as in the past, effective coast defense depends primarily on effective seacoast and antiaircraft armament, provided also that there be a sufficient number of trained coast artillerymen immediately available to meet any emergency.

The necessity for effective coast defense, in final analysis—efficient and sufficient coast artillery—has never been greater than it is today. Recent treaties, rather than lessening the importance of coast defenses, including fortified naval bases, emphasize their importance. The offensive power of our own and possible enemy navies is curtailed by treaty limitations on numbers and classes of ships. Coast defenses and fortified naval bases increase the offensive power of our Navy, so that today, with fewer ships, coast defenses and the Coast Artillery Corps take on an added significance, because they offer the one feasible as well as legal method by which to obtain the maximum effectiveness from our fixed battleship fleet strength. The result obtained through adequate coast defenses approaches the effectiveness of an increased fleet. This principle was recognized in the Armament Conference; it is recognized and appreciated by both Japan and England. In this connection recall the recent action of the British Empire in establishing an adequate fortified naval base at Singapore. By so doing, the British Empire secured for a fixed fleet strength an effectiveness impossible to secure otherwise, since an increased battleship fleet is prohibited by the recent naval agreement. Similar remarks apply to our established and prospective naval bases. If you would truly appreciate the significance of these principles to our Navy, ask them what we lost in naval effectiveness when we surrendered the right to fortify Guam, the Strategic Hub, so to speak, of the Pacific; ask them what naval effectiveness would be gained by a fortified naval base properly situated in the West Indies. The following extract from a special message to Congress on March 5, 1906, by President Roosevelt is of special interest as showing his knowledge and thorough appreciation of the importance of seacoast defenses:

"The necessity for a complete and adequate system of coast defense is greater today than 20 years ago, for the increased wealth of the country offers more tempting inducements to attack and a hostile fleet can reach our country in a much shorter period of time. The fact that we now have a Navy does not in any way diminish the importance of coast defenses; on the contrary that fact emphasizes their value and the necessity for their construction. It is an accepted naval maxim that a Navy can be used to strategic advantage only when acting on the offensive and it can be free to so operate only after our coast defense is reasonably secure and so recognized by the country."

Recognizing the above principles, we may assert with confidence that the mission of the Coast Artillery Corps in coast defense is of an importance in our settled national policy second to no other branch of the Army. While the mission of the Coast Artillery Corps in coast defense is definitely prescribed, an evident mistake is being made by failure to provide adequate means, particularly personnel, for the effective accomplishment of the assigned mission. At the present time the efficiency of our coast defenses and necessarily of our Navy, is seriously affected by lack of Coast Artillery personnel. While the importance of coast defenses is recognized and War plans indicate the major rôle of the Coast Artillery therein, nevertheless there is a failure to provide the peace time personnel necessary to accomplish the prescribed mission. Moreover, our service schools fail to emphasize the importance of Coast Artillery personnel and armament in coast defense operations. Certain service school coast defense problems fail to show Coast Artillery personnel and matériel as being available agencies to be employed. Witness the problem appearing in General Service School publication "Tactical Principles and Decisions," Vol. IV. This problem fails to show either Coast Artillery personnel or matériel as being available for use in the defense of the vicinity of Monterey Bay. The problem apparently was intended to illustrate the case of an attack on an unfortified harbor, yet not a single Coast Artillery unit is listed as being among the available defensive forces. The vicinity of Monterey lends itself exceptionally well to the use of railway and tractor artillery suitable for firing on moving naval targets. The very best defense under any such condition would be the installation and use of railway and heavy tractor artillery, converting the locality into a temporary fortified or strong point. By so doing the work of divisional troops would, to say the least, be greatly simplified. The best way to repel a seacoast attack is to destroy the attacking personnel while still on the water. Coast Artillery weapons and personnel are especially adapted to this mission, in fact, it is their *main job*. These suggestions are not inconsistent with the principles of "A Positive System of Coast Defense," as set forth in the official publication, "Joint Army and Navy Action in Coast Defense," which is now established doctrine. That Coast Artillery matériel and personnel are recognized as available agencies, auxiliary of course, (but essential auxiliaries), in these coastal operations is clearly indicated from the following quotation extracted from page 44, "Joint Army and Navy Action in Coast Defense."

"If his ships were held at a distance by the fire of heavy mobile artillery, he would be denied the necessary artillery preparation, because the guns of his fleet would be unable to deliver the observed fire required for the destruction of widely scattered machine-gun nests. He could expect but slight relief from the preliminary destruction of obstacles, as the attack of extensive belts of wire entanglement requires an accuracy of fire observation and an expenditure of ammunition that would probably not be within the capabilities of a fleet. He would probably be unprovided with or unable to make use of trench mortars and other special appliances recently developed for the attack of such positions. During his advance to the beach, his boats would come within the range of small and medium caliber guns that would suffer little from any counter battery effort from the fleet. Finally, on account of the extent and uncertainty of ranges and the flat trajectory of naval weapons, he would be denied any close artillery support at the moment of contact with his prepared enemy on the beach."

These facts have been universally recognized in approved war plans for the utilization of the Coast Artillery Corps in coast defense. It is of importance, however, that service schools emphasize them in instruction. Failure to do so is a failure to teach the use of the very best means provided for a particular purpose, and the effects may be far reaching, for unless service schools emphasize the importance of coast defense operations and indicate the proper rôle of the Coast Artillery therein, our coast defense sectors and sub-sectors may be commanded by officers who have no adequate grasp of the problems confronting them. We do not want to have a "Port Arthur" recorded in the pages of American history.

In this connection it is pertinent to remark that in the mimeographed Field Service Regulations prepared at the General Service Schools, the subject of Coast Defense Operations is restricted to a very limited discussion under the caption of *Special Operations*. It is believed that in the final publication of these Field Service Regulations, Coast Defense Operations should be emphasized as much as has been done by the official publication "Joint Army and Navy Action in Coast Defense." In fact, the inclusion of at least the subject matter of that pamphlet in Field Service Regulations would be a most effective means of insuring proper doctrine as to Coast Artillery personnel and matériel being made available to the service at large, including Service Schools and Commanders and staff officers of Regular, Reserve and National Guard Units allocated to important seacoast areas, especially the Pacific Coast area.

As before stated, the responsible rôle of the Coast Artillery Corps is recognized and prescribed in War Department plans. However, the policy which prescribes and the policy which provides are inconsistent. With an army of greater strength than in 1914 the personnel assigned to the Coast Artillery Corps in 1923 is less than in 1914, while at the same time the Coast Artillery Corps has logically been charged with the service of antiaircraft defense, which is of course an important element in Coast Defense. The peace time Coast Artillery is pathetically weak in numbers; so weak, that if the people throughout the country realized the conditions they could not possibly have that recognition of "reasonable security" which President Roosevelt believed to be so necessary in 1906. It has been shown that since 1906 the importance of coast defense has actually increased. These conditions are recognized by the War Department and provided for by large assignments of National Guard and Reserve Units to the Coast Artillery Corps. However, National Guard and Reserve Units cannot be made immediately available in case of emergency and it is essential that the Coast Artillery Corps have an increased peace time personnel adequate for the performance of its logically assigned mission.

Caretaker detachments are not skeletonized organizations that in emergencies can be quickly expanded into effective coast defense batteries; and coast forts, garrisoned by other than Coast Artillery troops, are not a defense against hostile fleets, although the public may not yet realize this fact. With the present assignment of regular Coast Artillery troops, and the relatively few National Guard Coast Artillery who are highly trained, it would take some months before this force, supplemented by the large number of National Guard and Reserve troops which would be assigned to the Corps, could effectively man our coast and harbor defense armament. Evidently, this is a lamentable condition of affairs, as proper defensive security dictates that the Navy and the Coast Artillery be prepared and ready at the outbreak of hostilities—not some months later. Give this preparation to our coast defenses, and other branches of our army will have the necessary time to mobilize and train, for our Navy will be free to carry out its true mission. The truth of these statements is so evident that it cannot long be ignored. There is every indication that a wiser policy in reference to coast artillery personnel is near at hand. The Navy is reluctantly admitting that the present army coast defense measures do not satisfy their requirements. This state of affairs is emphasized by recent Panama Maneuvers, which showed the necessity for additional antiaircraft artillery and high powered seacoast armament.

There is a more or less popular belief that our present fixed defenses are obsolete. This fallacious belief is accentuated by the abandonment of many of our coast forts, due to shortage of Coast Artillery personnel, and turning them over to other branches of the army to be garrisoned. These defenses, generally speaking, if adequately manned are far from obsolete, for battle decisions will still be reached within their limits of range. Moreover, many statements as to vulnerability of certain of our older fixed batteries to air attacks are misleading. These batteries are not so vulnerable as many would have us believe, for they can be defended against air attacks by the same methods that are used in defense of the newer batteries. In connection with our present coast defenses, it is interesting to note the statement of a high ranking army officer, a recognized authority on international affairs, in commenting on the effects of treaty limitations in naval armaments. This officer advances the belief, shared by many others, that any limitation in the size and number of ships has tended to rehabilitate, as it were, our present coast defenses, which are certainly equal to the attack of the older and lighter armed vessels. He further believes that if not allowed in time of peace to build large ships, armed merchant vessels will become effective men-of-war, and against these ships our present coast defense armament is more than adequate, and will be needed. In any case our present defenses, adequately manned, serve a useful purpose. Such defenses, supplemented by a few long range guns fixed and mobile, with mobile high power guns now available, merit such reapportionment of the present army strength as will provide a more effective peace time Coast Artillery. The importance of coast defense is such as to dictate that Coast Artillery personnel needs be the first to be filled. Troops so assigned can quickly be converted to other uses in case of emergency, but the converse is not true. These facts have not been appreciated. Given sufficient Coast Artillery personnel, our coast defense system, the most vital army element in our National Defense Policy, will be as efficient now as it was in 1914, when our harbor defenses were efficiently manned and considered the best in the world. That our coast defenses are not so efficient today is due primarily to the late war, as a result of which too much consideration has been given the special case of land warfare in France, waged by us with Great Britain commanding the seas. Erroneous conclusions have been voiced helter-skelter as to the mission and effectiveness of coast defenses adequately manned in peace time. The recent war upset many ideas and convictions as to efficiency of arms and the manner of conducting operations, but the war in no way upset the fundamental principles which for our country dictate an efficient coast defense system. Moreover, the methods employed by the Coast Artillery in 1914 are just as sound today as then, for the war changed no fundamental principles of Coast Artillery technique.

The present policy which has limited Coast Artillery personnel to an ineffective peace time force is unsound and not consistent with our National Policy. This condition will be changed sooner or later. When the public realizes just the present condition of affairs there will be a demand for effective coast defenses which neither the War Department nor Congress can ignore. At present the public, trusting Congress, rests secure in the belief that our defenses are adequate. One of these days there will be an awakening. The signs of the times point that way. A few days ago the New York Times quoted the Secretary of War as stating that "he was humiliated when he was greeted at Fort Rosecrans, supposed to protect the harbor of San Diego, by a guard of 13 men." He further stated, "I don't know where we are going to get the men to man the large number of forts throughout the United States and its insular possessions. I admit that San Diego should be properly defended and should have the proper number of men."

The situation which the Secretary of War portrays as existing at San Diego is typical of the condition which exists at every fortified point in the continental United States. Because of this condition, brought about by the policy which provides inadequate personnel to the Coast Artillery Corps for the performance of its mission, the Chief of Coast Artillery reported in 1922, that strong points (fortified harbors) are strong points in name only, due to lack of personnel. The defective policy that brought about this condition is being recognized by those who can bring about remedial action. Shortly before his death, General Grant wrote "We should have a good Navy, and our seacoast defenses should be put in the finest condition." In a few words General Grant outlined the essence of a proper military policy for a nation whose national policy is defensive and two of whose frontiers are seacoasts.

EDITORIAL

True Service for the Queen

IN the JOURNAL for June, 1919, appeared an editorial entitled "The Queen of Battles." From this editorial the following two paragraphs are quoted for consideration at the present time:

"This last war and every other war of any magnitude was not won until the Infantry, assisted by all of its many aids, had imposed its will on the enemy's infantry. Let us not forget this. Let us never be led astray by false prophets or men who, immersed in the study of their own arm, forget this fundamental fact of war. If you belong to an auxiliary arm you must subordinate your training, your organization, and your thoughts to the needs of the Infantry. Only by such a policy can you hope to be of adequate use to the arm for whom you exist.

"This proper relation of all arms to the Infantry goes much farther in its application than to Divisions, Corps, and the Army. It extends throughout all our means and organization for carrying on war. We have said that the decision is only reached by Infantry action. This is true in any case. A Naval engagement simply decides upon whose soil the final battle will be fought. A harbor defense action will in the end simply determine whether the *Infantry* of the enemy will land conveniently in a sheltered port at his pleasure, or be forced to come ashore on the beach to the great advantage of our *Infantry*. If we gain control of the sea we will invade the enemy to secure a decision with our *Infantry*, and *all* arms, as aids, will accompany it. If we lose control of the sea we will be invaded, and all arms, as aids to the Infantry, will take part in the struggle with the invading force. In either event there is no arm, no soldier, no camp follower who does not owe his allegiance and the subordination of his spirit to the arm for whose aid he is created."

The doctrine which was intended to be imbued by the publication of this editorial is a sound doctrine for every branch of the service to follow; as much so today in the cool reaction of peace, as it was when the editorial was written, with the flush of victory still in the blood of all Americans. In this editorial was acknowledged the claim long made by the Infantry itself that the Infantry is "The Queen of Battles." In its fundamental aspects the point of view expressed in the quotation above presented, is still sound. Nevertheless, it is true that nothing written or spoken at any time carries the stamp of absolute finality.

In connection with the re-examination by the Coast Artillery Corps of its mission, its means, and its place in the sun, we should now criticise and amplify our own earlier statement. When the statement was made "a harbor defense action will in the end simply determine whether the Infantry of the enemy will * * * * be forced to come ashore on the beach to the great advantage of our Infantry," an under-statement was made of the true service which should be rendered by the Coast Artillery to "The Queen of Battles." Again, when in the same paragraph the assertion was made "if we lose control of the sea we will be invaded, and all arms, as aids to the Infantry will take part in the struggle with the invading force," there was the same failure to conceive the initial responsibility of the Coast Artillery Corps, in its service to the Infantry.

The point involved may perhaps be illustrated thus: if along an Army defensive front in land warfare, a hostile attack is launched against a portion of the Infantry's main line of resistance, there be timely response by the Field Artillery to the call of the Infantry, so that the defensive barrage breaks up the hostile attack before it reaches the position of our Infantry, all hands realize that the Field Artillery in this instance has done true service to "The Queen of Battles," and the Infantry need not and will not feel chagrined that the interposition of the Field Artillery has rendered it unnecessary for the Infantry to demonstrate its pre-eminence in bloody combat which would involve the loss of Infantry lives. Very well, in somewhat parallel fashion, if an enemy proposes to invade our land by way of a maritime frontier, will not the Coast Artillery perform an equal service to our Infantry, if by the fire of its mobile high powered artillery, a hostile fleet can be held so far off shore as to prevent it from bringing its transports close to shore and covering with naval gun fire the landing of troops on the beach? If mobile guns on tractor and railway mountings can be concentrated in sufficient numbers to hold the transports off shore and to sink the small boats of the attackers before they reach the shore, the lives of our Infantry will be saved, and the defense will be truly successful. By the methods of fire which the Coast Artillery has developed, it is demonstrable that at least in a large proportion of the conceivable situations of this sort which may arise, an adequate number of Coast Artillery weapons could prevent a hostile attack from ever getting its feet on shore. Whenever Coast Artillery gun fire can accomplish this achievement, our Infantry will be truly served in the consequent saving of Infantry lives.

Now this line of thought should not be misinterpreted nor misunderstood. It is clearly conceivable that there may be many possible situations where the Coast Artillery could not prevent a hostile attack from getting a foothold on shore. Aside from the immediate reason that at the critical time and place it might not be possible to concentrate enough Coast Artillery guns and men, to accomplish this end, there are also the conditions of invisibility through smoke or fog which would permit the close approach of hostile transports and landing parties in small boats, under such cover that guns could not be laid and fired at effective ranges. Furthermore, although this condition is less likely, there are conceivable landing places on our shores which are not approached by roads or railways which are necessary for the access of many of the types of mobile high powered guns manned by the Coast Artillery Corps. In the face of these limitations and possibilities the issue finally leads back to the reliable "Dough-boy," the sturdy son of "The Queen of Battles."

Nevertheless, if we grant the possibility of occasions when Coast Artillery gun fire could prevent a landing of hostile Infantry and field guns, it seems no more than fair to assert that the Coast Artillery Corps should prepare itself to accept the specific responsibility of preventing landings by gunfire, and that our whole national doctrine of coast defense should recognize and demand the acceptance of this responsibility under the possible conditions where it can be exercised on the part of the Coast Artillery Corps.

Perhaps the greatest single advance made in the history of American defense policy resulted from the publication of the pamphlet "Joint Army and Navy Action in Coast Defense." In this pamphlet for the first time has been enunciated a clear statement of the separate and mutual responsibility of the Army and of the Navy, and of the procedure whereby this policy is to be made effective. Especially when we stop to consider that the entire military and naval policy of the United States is dictated by the attitude of the American people to be a defensive one, and that two of the four frontiers of the continental United States, all of the frontiers of our Insular Possessions, and the only two vulnerable frontiers of the Canal Zone are maritime frontiers, we may realize that the publication "Joint Army and Navy Action in Coast Defense" is one which should be most carefully studied in all its aspects by every officer not only in the Coast Artillery Corps, but in every other branch of the Army. For the time being this pamphlet is a veritable Bible. Nevertheless, we recognize that it is not a piece of Holy Writ, and that by very reason of its importance, it should be subjected to the most careful scrutiny, with a view to assuring the soundness of its dicta. On page 38 of this pamphlet occurs the following statement: "It is proposed to show in this memorandum that by a properly organized system of beach defense of the favorable landing places near all vitally important objectives it will be possible positively to secure the United States against invasion from the sea, even should we lose command of the sea in both oceans." This quotation embodies a concise statement of the mission and responsibility of the army with regard to coast defense outside the immediate areas of harbor defenses. The latter part of paragraph 14 from page 44 of this pamphlet quoted in full on page 58 of Major Welshmer's article in this issue of the JOURNAL sets forth the desideratum that a landing be entirely forestalled by the fire action of heavy mobile artillery. Nevertheless, a careful perusal of the entire pamphlet will convince the reader that the authors of this pamphlet did not have sufficient confidence in the ability of mobile high powered artillery to prevent a landing, to prompt them to prescribe this responsibility as a function of the Coast Artillery Corps, or to influence materially their development of technique in "A Positive System of Coast Defense." This attitude on the part of the authors may be inferred quite explicitly from the portion of paragraph 23 on page 50 quoted as follows:

"*Movable heavy artillery.*—In many cases movable high-power artillery will form an important auxiliary for the mobile detachments assigned to beach defense. Such weapons will increase the difficulty of hostile landings by keeping hostile warships at a distance from certain particularly favorable beaches. Artillery of this type should, however, be regarded purely as an auxiliary. Except as auxiliaries to mobile forces, they will have no conclusive influence on coast defense, and, on the other hand, mobile forces equipped with the usual field artillery types will generally be sufficient for the purposes of the defense even without the intervention of the heavier types. Another important rôle of these heavier weapons will be in the reenforcement of the armament of existing harbor defenses and as auxiliaries to the field army wherever siege operations may develop."

Now it is admitted that within certain limitations, the Coast Artillery Corps can be and should be charged with the responsibility of absolutely preventing a landing on our shores. Supposing that in the event the Coast Artillery fails? Well then—the Infantry would at least be no worse off, and by reason of the previous insistence of the Infantry that the Coast Artillery be on hand to do its best, such fire as the Coast Artillery will have executed should render the task of the Infantry easier than though the Coast Artillery had not been asked for and had not been there at all. To the serious student of this extremely important aspect of our National Defense is commended not only "Joint Army and Navy Action in Coast Defense," but as well Major G. Ralph Meyer's article entitled "Heavy Tractor Artillery in its Relation to Coast Defense," in the June issue of the JOURNAL, and especially his constructive suggestions on page 531 *et seq.*, which fit in directly with Part IV of "Joint Army and Navy Action in Coast Defense."

It has been said that the serious consideration of "Joint Army and Navy Action in Coast Defense" is important not only to Coast Artillery officers but to officers in all other branches of the Army. By very reason of this fact, it seems important that the terminology in this pamphlet should be uniform with the terminology used throughout the rest of the service, in order that there may be no chance for misunderstanding as between officers of different branches of the service. For instance, on page 10 occurs the statement "According to the foregoing, a defense sector comprises the entire sea frontier within its limits, of which the harbor defenses are *strong points* (Editor's italics) and not isolated points to be defended." The same statement occurs again on page 55. Now, as defined on page 53 of the General Service School's publication "A Textbook on Field Fortifications,"

"The strong point is composed of several combat groups distributed both in width and depth, and under the command of a single officer. Although the normal garrison of a strong point is a company, in special situations it may be held by a force varying from two platoons to two companies depending on the terrain, the size of the defensive force, and other elements of the tactical situation."

This definition, especially as understood with its context which defines *combat groups* and *centers of resistance*, embodies a conception of the size and function of a *strong point* which is very well understood throughout the Army and which is in every way distinct from the organization, size and function of a harbor defense, referred to as a strong point in "Joint Army and Navy Action in Coast Defense." A serious comparison between the functions of a strong point and of a harbor defense, will convince the reader that the criticism implied in thus pointing out this difference is prompted not by a quibbling spirit, but a desire that there should be no misunderstanding on the part of anyone as to the real function of a harbor defense. As time goes on, it should become apparent that there are other points which need not here be enumerated, in which the phraseology and the prescriptions of "Joint Army and Navy Action in Coast Defense" can be modified in the direction of improvement.

If the reader has had the patience to tarry thus far with this screed, he may be prepared for the statement that its real purpose is to remind Coast Artillerymen that for the particular weapons at their disposal there is work to be done and a mission to be executed, which is broader than has in all cases been appreciated either by Coast Artillerymen or others, a work to be done which no other Corps can do as well. Not all Coast Artillerymen need to be informed or confirmed in their belief as to *The Importance of Coast Artillery in our National Defense*, but even those who do not need so to be convinced will read with profit and interest Major Welshmer's article on this subject in the present issue of the JOURNAL. What all of us do need to realize is the full extent of responsibility which the Coast Artillery should be prepared to accept in National Defense, if given the adequate means and opportunity. Those of us who believe with Major Welshmer, that at the present time the Coast Artillery Corps is being afforded but scant means to prepare for the acceptance of its ultimate responsibility, must nevertheless frankly realize that the present condition of affairs is one which is the logical result of circumstances, many of them harking back not only to the World War, but to 1907 and earlier. The immediate and pressing need is that Coast Artillerymen themselves should unitedly join in the clear thinking which will lead us to a common conception of what the doctrine of National Defense should be in its relations to distinctly

Coast Artillery effort, so that we may be able as the occasion affords to present the Coast Artillery case with confidence and fairness. It has been truly commented by many Coast Artillerymen that the Coast Artillery phase of national doctrine has not as yet been completely set forth in any form upon which all thinking Coast Artillerymen may agree. This observation is true, but is not by any means to be considered a cause for pessimism. The fact of the matter is that there is probably no other branch of the Army whose problems have been so widely extended as have ours. This extension of our problems has occurred through the impacts and reactions of the changed conditions of Naval warfare, the tremendous increase in variety, power and range of all our weapons, the influence of aviation and chemical warfare, and above all by the promulgation of "A Positive System of Coast Defense." All these impacts and reactions are but a challenge, and if the challenge can not be met in a day, we need not be depressed, but should be stimulated to a heightened endeavor. Nevertheless, the very combination of facts that in all its phases, Coast Artillery doctrine regarding technique, command, and our relations with other arms, is not finally perfected, coupled with the fact that the Coast Artillery today is in many respects laboring at a disadvantage, demands that Coast Artillerymen everywhere bend their keenest energies to the moulding of a common opinion which we will be prepared to back to the limit of our powers. Never was there a time when a greater need existed that all Coast Artillerymen should be Coast Artillerymen in fact as well as in name. It is true we are first of the Army, but let us never forget that as loyal and efficient Coast Artillerymen we will best serve the Army, and prove that the Coast Artillery Corps is an indispensable servant to the "Queen of Battles."

The Journal Needs Translators

Through its exchanges and otherwise there is constantly coming to the COAST ARTILLERY JOURNAL a mass of valuable material in foreign languages, much of which would no doubt be of extreme interest and great value to Coast Artillerymen. Through the cooperation of numerous officers, the JOURNAL is able to obtain translations and digests of some of this material, particularly in the German, French and Italian languages, but the Editor would appreciate the services of several more officers who would be willing to undertake translations from these three languages and in addition there is an especial need for the same kind of assistance with regard to publications from the Danish, Swedish, Norwegian, Spanish and Portuguese languages. Accordingly, it is requested that any officers who would be willing to undertake work of this kind communicate with the Editor. It is believed that much of the material now becoming available in foreign publications reflects the digested experience of the World War to an extent that should make its perusal of distinct interest to the translator, and unquestionably of great value to the Coast Artillery Corps as a whole.

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The Beaten Zone

With something like a sigh of relief the announcement is offered that *The Beaten Zone* makes its last appearance with this issue of the JOURNAL, for the time being at least. It is probable that some months hence, through the cooperation of Major Oliver L. Spiller, commanding the 61st Artillery Battalion, Antiaircraft, there will be presented a short course of map problems in the tactical employment of an Antiaircraft Artillery Regiment, paralleling the course just being terminated in the employment of tractor and railway artillery. With the exception of such an antiaircraft course, it is believed that the mission of the Beaten Zone is accomplished. When the Beaten Zone was inaugurated, in March 1920, the War Department correspondence courses for Coast Artillery Reserve Officers had not been established, there were many essential elements of Coast Artillery technique which seemed to be in a state of flux, and for which at any rate no adequate and up to date texts had been prepared, a need for actual problems to be used in R. O. T. C. instruction had been expressed, and within the regular Coast Artillery Corps itself there was a considerable proportion of commissioned personnel of limited experience and training. Today the official correspondence courses are in operation, Coast Artillery technique is in a fair way to standardization, and numerous Coast Artillery texts have been published, R. O. T. C. instruction has become well organized, and through practical experience and attendance at the Coast Artillery School, the commissioned personnel has shaken down to a desirable standard of familiarity with our especial technique. Consequently, with the passing of the temporary conditions which seemed to render the Beaten Zone enterprise desirable, this department may well give way to afford space for more pressing matter. During its career the Beaten Zone has included courses in adjustment of fire, gunnery, antiaircraft gunnery, orientation, administration, and the employment of heavy artillery. All of these problems were produced under pressure and never presumed to represent perfection, If to some extent, here and there the work of Coast Artillerymen has been lightened or supported, the Beaten Zone may now be discharged—"service honest and faithful."

COAST ARTILLERY BOARD NOTES

"Communications relating to the development or improvement in methods or materiel for the Coast Artillery will be welcome from any member of the corps or of the service at large. These communications, with models or drawings of devices proposed may be *sent direct* to the Coast Artillery Board, Fort Monroe, Virginia, and will receive careful consideration."—

JOURNAL OF U. S. ARTILLERY, June, 1922.

Work of the Board for the Month of May, 1923

A. New projects initiated during the Month of May, 1923.

1. Project No. 122. Range Corrector for 155-mm. Guns.—See Figure 1. This device consists of an hexagonal shaped pulpboard base, on which is mounted in a recess, a circular piece of pulpboard. Curves of ballistic effects are plotted on the face of the circular pulpboard. Opposite the periphery of the circular board and on the base is a scale of yards for plus or minus corrections. A radial arm of xylonite is graduated in range. The radial arm is brought to an intersection with a selected curve at the proper range and the resulting correction is shown at the periphery of the circle. The algebraic sum of the corrections is applied to the true range.

The corrector is designed to avoid computing initial ballistic corrections and to obtain a range correction rather than a corrected range as is the case in general use of the comparatively expensive Pratt Range Board.

Two of these devices have been issued to the 155-mm G.P.F. batteries at Fort Eustis for test at target practice.

2. Project No. 123. Percentage Range Elevation Devices.—This is a consideration of means for fixed and mobile artillery of applying ballistic and arbitrary corrections as a percentage of the range. The Pratt Range Board, or a modification of it, or the circular range corrector described in Project 122 may be used to obtain the initial ballistic correction. This correction, together with the arbitrary corrections obtained during adjustment fire, may be applied through an equicrescent scale to a logarithmic scale of ranges. Corrections applied in this manner will vary as percentage corrections and will hold true for a considerable change in range, or until new ballistic or arbitrary corrections have been determined. Devices for accomplishing this will be tested by the Railway and Tractor Artillery units at Fort Eustis, and by fixed batteries at Fort Monroe.

3. Project No. 124. Battery Charging Plants for Small Tactical Units.—The specifications of a small electrical plant for charging storage batteries were submitted for comment. The Board found that the charging set described was not adapted for use by the Coast Artillery. It was too heavy to be carried conveniently to outlying stations and did not have sufficient power to charge the relatively heavy batteries used near the guns. The Coast Artillery is not particularly interested in the development of very small charging sets.

4. Project No. 125. Type EE-8 Telephone, Signal Corps.—This is a local battery telephone intended for field use by all arms. Its weight is 14 pounds. It is equipped with a handset, an additional band type watch case head receiver,

and a plug and jack for use in connection with a gas mask or other extra transmitter.

The Board has recommended approval of the design and the use of the fibre covered wood case in preference to the leather case.

5. Project No. 126. Extension of 6-inch elevation Tables.—Because of the modification of certain 6-inch batteries to permit an elevation of 20 degrees, new elevation tables are required extending graduations on range drums. These tables have been prepared.

6. Project No. 127. Review of Training Regulations, No. 435-210, Gunnery for Antiaircraft Machine Guns.—These regulations are being studied by the Board.

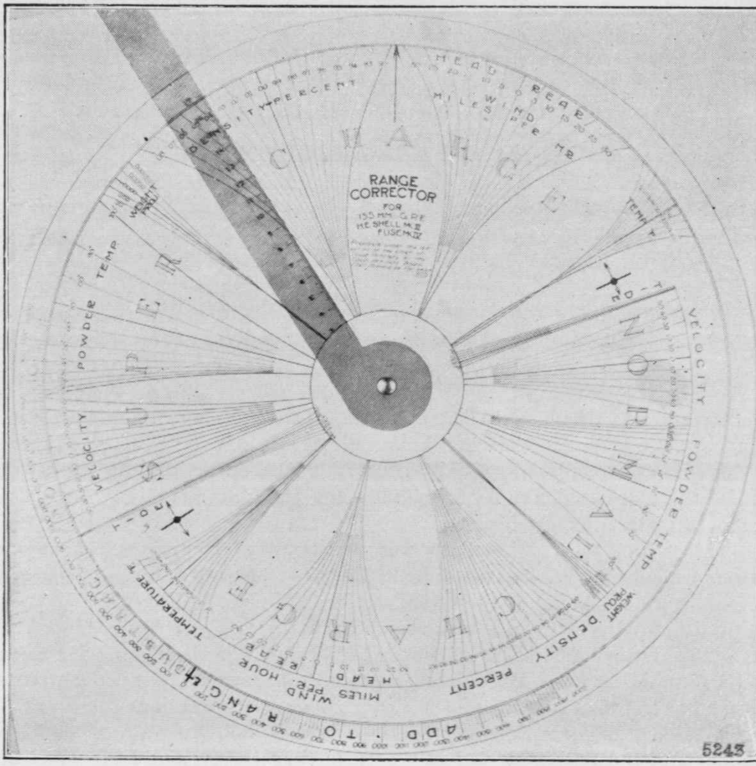


FIG. 1.

7. Project No. 128. Manual for Coast Artillery—Air Service Cooperation. As a result of the Joint Coast Artillery—Air Service Maneuvers of October-November, 1922, The Adjutant General has directed that this manual be prepared. It is intended that eventually the subject matter of the manual will be included in Training Regulations. The manual is to be prepared by the Coast Artillery Board in collaboration with the Commanding Officer, Langley Field.

8. Project No. 129. Angular Units of Measurement for Coast Artillery.—This is a study of the feasibility of converting all Coast Artillery matériel to a singl eunit of angular measure. It appears that as between mils, degrees and hundredths, and degrees and minutes, no material advantages are possessed by

one over the other from the viewpoints of accuracy, convenience, or adaptability to field conditions. The recommendations for a choice of unit will be governed by such considerations as wartime supply and training, and the cost of converting matériel to a selected unit. The adoption of a single unit for the measurement of vertical as well as horizontal angles has been recommended. After data as to conversion cost, and wartime supply have been obtained, a particular unit and a conversion policy to that unit will be recommended.

9. Project No. 130. Training of Meteorological Details.—The proceedings on this Project as submitted to the Chief of Coast Artillery are as follows:

a. General discussion and conclusions.—

The Coast Artillery Board is of the opinion that steps should be taken to insure the proper use of meteorological equipment issued to Coast Defenses; that sufficient personnel should receive training in meteorological work to insure the procuring of meteorological data for target practice; that a knowledge of the fundamentals of meteorology and the securing of meteorological data should be made more general throughout the service.

The subject of "Meteorology" will be covered in the Training Regulations to be published under that title and is at present sufficiently covered in a printed pamphlet entitled *Meteorology for Coast Artillery* published by the Coast Artillery School. This pamphlet is comprehensive in its scope and includes a general discussion of the subject, the use of meteorological instruments, and the duties of a meteorological detail. This pamphlet should be distributed to the various coast defenses.

It is understood that the Signal Corps has expressed a willingness to enroll students for a course in Meteorology in the Signal Corps School at Camp Vail. This course should be sufficient for the training of selected enlisted men as meteorologists.

The Board is of the opinion that a continuous record of atmospheric changes should be kept in each major coast defense, the extent and comprehensiveness of this record to be determined by the amount of time and the size of the detail available for meteorological work. The work of the meteorological details should be subject to careful and regular supervision by a central agency in order that a high standard may be set and maintained.

It is believed that the meteorologist should be a Master Gunner as Master Gunners generally have the necessary reliability, skill, and intelligence for this kind of work, their previous training in surveying would be of considerable help, and they would be available for short periods daily for meteorological observations and instruction.

b. Recommendations.—

That a course in Meteorology be included in the curriculum of the Enlisted Specialists School at Fort Monroe for Master Gunners to insure the eventual presence of trained meteorologists in all coast defenses.

Pending the graduation of trained meteorologists, (Master Gunners) from the Coast Artillery School it is recommended that arrangements be made with the Signal Corps for the instruction of selected enlisted men in meteorology at Camp Vail.

If this arrangement can be made, each major coast defense having no trained meteorologist at the present time, should send to the Signal Corps School for Meteorology one Master Gunner or a graduate of the Master Gunner's Course for whom no vacancy in the grade of Staff Sergeant (Master Gunner) is available.

On successful completion of the course at Camp Vail these men should be returned to their proper stations and be made Coast Defense Meteorologists.

Each Coast Defense, other than those in charge of caretakers, should then have a meteorological detail. The other members of the detail can be selected from special duty men who can perform the work required in addition to their other duties. The supervision of the meteorologist and his detail should be made a part of the duty of the Coast Defense Signal Officer. The size of the meteorological detail and its hours of duty at any Coast Defense should be prescribed by the Coast Defense Commander. It is considered desirable to have a detail of four men in addition to the meteorologist if this number be available; viz., observer, reader, plotter, and assistant plotter. A continuous record of atmospheric conditions and observations, including balloon flights for ballistic wind, should be made at least twice daily. The prescribed minimum for any major coast defense should be a detail of two men making one observation daily, the limiting factor being time and personnel available. Prior to the annual target practice this detail should be increased to insure accurate meteorological data during the target practice period.

It is further recommended that Coast Artillery meteorological work be coordinated with that of the Signal Corps; that a continuous record of observations be made on forms to be prescribed for that purpose by the Signal Corps and that this record be submitted to the meteorological section of the Signal Corps thru the Chief of Coast Artillery; that coast defense meteorological work be supervised by the Signal Corps Meteorological Section.

10. Project No. 131. Panoramic Sights for Mobile Artillery.—The standard panoramic sight for railway and tractor artillery usage is not suitable for fire at moving targets using an aiming point (Case III.) It is desirable, that when the sight is laid on the aiming point it will read the azimuth of the set-forward point when the axis of the bore is laid on the set-forward point. The direction of the azimuth circle graduations on standard panoramic sights will not permit this. It has been found necessary to reverse the direction of the graduations and to include an adjustment for the azimuth circle ring. A modified sight will be recommended.

11. Project No. 132. Fire Adjustment Device.—A device which contains an impact chart and a means of determining impact of recent shots by visual inspection, and for applying corrections during continuous fire. is under consideration.

12. Project No. 133. Azimuth Origin for Coast Artillery.—The proceedings on this Project as submitted to the Chief of Coast Artillery are as follows:

a. General discussion.—

(1) The Coast Artillery Board considered the fact that all other branches of the army measure azimuth from the North and that this origin is used by all units of the Coast Artillery Corps except those in fixed defenses. Signal Corps meteorological messages are based upon the North point. A common language with all the other branches is of course desirable if not too expensive to obtain under the present conditions in the Coast Artillery.

(2) (*a*) Considering the feasibility of making a change in the azimuth origin at Fort Monroe. Virginia, for example, it appears, that in addition to the clerical labor required to change all posted orientation data to correct maps, etc., some modification in the matériel will have to be made locally.

(*b*) In the case of the mortar batteries, Anderson and Ruggles, the changes to North azimuth origin will be inexpensive. The azimuth circle is exposed and by removing the securing screws the brass sections can be removed and placed in the new positions. New holes for the securing screws may have to be drilled and tapped. The index box for the azimuth circle will not need to be moved because it is located for convenience in pointing the piece into the field of fire regardless of the azimuth origin. A somewhat similar condition exists at Battery Bomford 10-inch Rifles (1894 D.C.).

(*c*) At the 10-inch batteries, Eustis and Church (1896 D.C.) the azimuth circle cannot be removed nor shifted 180 degrees without dismounting. It is possible, however, to effect the conversion without dismounting. The present numbering to the graduations on the brass azimuth circle can be buffed off without affecting the utility of the graduations. The circle can then be renumbered.

(*d*) The three 12-inch guns at Battery DeRussy are on 1897 D.C. and the azimuth circles can not be removed nor shifted without dismounting. A conversion similar to that mentioned in (*c*) is possible.

(*e*) The two 12-inch guns at Battery Parrott are mounted on 1901 D.C. and while there is some prospect of being able to remove the securing screws and shift the azimuth circle sections until the unmarked graduations are in the new positions it is considered better to buff off the numbering and renumber as mentioned above.

(*f*) The ordnance machinist at Fort Monroe estimated the cost of this conversion in (*c*), (*d*), and (*e*), at $100 per carriage.

(3) It appears that the azimuth circles on all fixed artillery heavier than the 6-inch gun will require modifications.

(4) (*a*) The present Whistler-Hearn plotting boards will require modification. The zinc azimuth circles will require replacement and restamping and this cost will have to be charged against an azimuth origin conversion policy except in those cases where Whistler-Hearn plotting boards are converted to the Cloke principle.

(*b*) The 110 degree plotting boards, in general, will not require replacement of azimuth circles. It is understood that the azimuth circle graduations on all 110 degree plotting boards are identical, i.e., the 1st, 2nd, 3rd and 4th quadrants are common to all boards. In this connection, it may be advisable in the batteries where the normal field of fire lies in the overlap of quadrants to make the change in quadrant graduations of the 110 degree boards which is best suited to the battery concerned, ulness it is proposed to substitute eventually a Cloke Board for the 110 degree board at that particular battery.

b. Conclusions.—

(1) That a common azimuth origin throughout the Coast Artillery is desirable.

(2) That the azimuth origin for Coast Artillery preferably should be the same as the origin used by the rest of the army.

(3) That the azimuth origin for Coast Artillery should be the true North because:

(*a*) Exchange of information with mobile elements of the Coast Artillery will be made easier. The mobile elements can use conveniently the same origin when serving as army artillery in the field or when serving with the fixed defenses.

(*b*) Exchange of information with other branches of the Army will be made easier.

(*c*) It will be less confusing than the South azimuth origin in the training of Coast Artillery National Guard, Reserve, R.O.T.C. and emergency personnel made up of American engineers and other professional men whose general conception of azimuth origin is the North point.

(4) That the change from the South to the North azimuth origin will entail some expense; but the cost of the change will depend upon whether the mil is adopted as standard for all Coast Artillery units, and on the conversion policy for changing to the mil. In this connection see Coast Artillery Board Project No. 129.

(5) That the cost of effecting the change from the South to the North origin should be estimated and a conversion policy formulated upon:

(*a*) Adoption of the mil as standard for Coast Artillery.

(*b*) Adoption of degrees and hundredths as standard for Coast Artillery.

(6) That a change from the South to the North azimuth origin will require considerable labor in the change of all orientation data now posted in fixed coast defenses, and the correction of all Coast Defense maps and coordinate systems. The cost of this labor will, in the main, come under overhead and will not require a special appropriation.

(7) That regardless of the unit of angular measure adopted (CAB Project No. 129) the azimuth origin in Coast Artillery should be the North point and the labor and expense necessary to effect this change will be justified by the uniformity secured.

c. Recommendations.—

(1) (*a*) That the Office of the Chief of Ordnance be requested to furnish an estimate of the cost of converting all fixed, non-obsolete Coast Artillery matériel to the North azimuth origin.

(*b*) That this cost be tabulated by forts and Coast Defenses.

(*c*) That an estimate conforming to (*b*) as to the time required to effect the conversion be made so that a conversion policy can be formulated.

(2) That a conversion policy be formulated after action has been taken upon Coast Artillery Board Project No. 129, Angular Units of Measurement for Coast Artillery.

(3) That the azimuth origin in Coast Artillery be the true North and that conversion, where necessary, be made to that point.

B. Projects previously submitted on which work has been accomplished.

1. Project No. 3. Effects of Heavy Artillery Fire on Fire Control Communications.—Communication lines were installed at Fort Eustis as shown in Figure No. 2. This figure also shows location of bursts with respect to communications lines.

Referring to Figure No. 2, the several installations were:

A—Open wire line, 10 No. 14 GI wires, 10 pin telephone crossarms, 20 ft. poles with 5 inch tops, end guyed, crossarms braced, pony glass insulators.

B—Open trench 4½ ft. deep by 2 ft. wide, waste thrown up on side C. On one side, 5 No. 17 copper-clad tw.pr. lines on wood knobs attached to wood posts at 20 ft. intervals; also 5 tw. pr. field lines on same posts. On the other side of trench, a 25-pr. lead covered, paper insulated cable and a 10 pr. Ferrin circular loom cable laid on a shelf in the bank 2 ft. from the bottom of trench.

C—A 50 pr. paper insulated, lead covered, armored cable buried 2½ feet deep.

D—One 3 in. gas pipe and a concrete block containing one fiber and one tile duct. A 50 or 25 pr. paper insulated, lead covered cable in each of these three ducts. Ducts buried 2½ feet.

E—5 No. 17 copper clad and 5 field wire twisted pair circuits on wooden knobs supported by horizontal bars on two posts 4 feet high.

Twisted pair circuits were laid on the ground, copper clad and field wire alternately. These are not shown in Figure 2.

The above installation was included in an area of about 300 feet by 240 feet.

Ninety rounds of high explosive 155-mm. shell were fired in this area with the idea of causing the maximum damage. Range about 6300 yards, angle of fall 314 mils.

The overhead high pole lines (A), suffered the most damage, the wires being cut by flying shell fragments.

The low overhead line (E) sustained the next most serious damage, all lines being cut.

A direct hit was secured on trench D making a crater equal in depth to the depth of the trench. The hit centered on the duct lines, it destroyed the concrete block, the fiber and tile ducts and severed cables contained therein and destroyed the cable in the adjacent 3-inch iron pipe. Another direct hit was secured on this same trench but did not penetrate far enough to do any damage to the buried cable.

A hit was secured on trench C. It did not center on the cable but the cable was exposed on the side of the crater. The cable was not damaged.

In the open trench B only the two top twisted pair were cut. The cable in this trench sustained no damage. No direct hit was secured in this trench but projectiles burst very close to it, as shown in Figure 2.

The ground wires were all cut.

As a result of this firing the Coast Artillery Board submitted the following conclusions and recommendations:

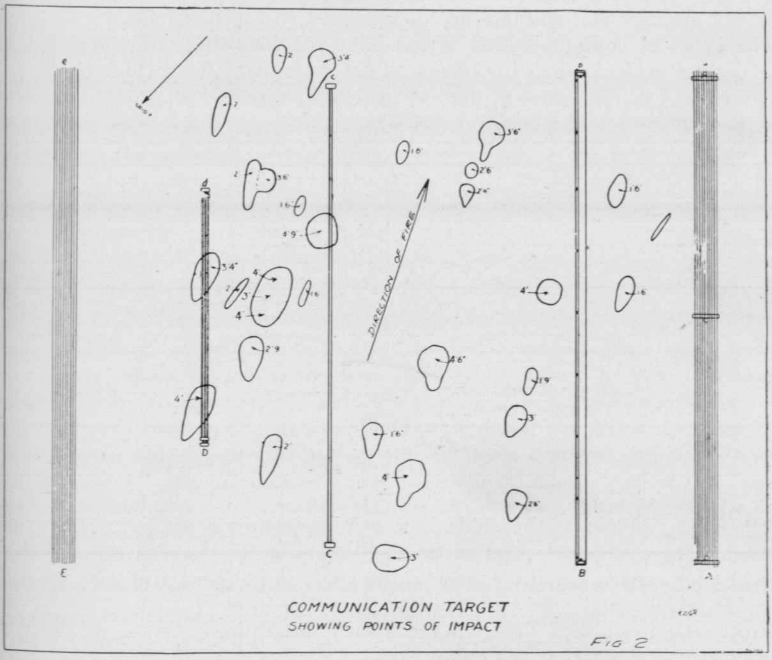


FIG. 2.

Conclusions.—

Damage to communication systems from artillery fire falls into one of the following three classes: Damage by direct hits, by explosive force, by shell fragments.

The danger zones for damage in the three ways mentioned above may be represented as shown in Figure No. 3.

The delay action of the fuse, the angle of fall, the fragmentation qualities of the shell, the weight of shell, the weight and type of explosive charge, and the nature of the ground are all factors that will alter the shape of the danger zone and the chance of hitting within that zone. but in general the danger zone above ground will be greater than that below ground.

Armored lead cable, paper insulated, suffers less damage than any other usual type of communication system.

Any type of communication lines are satisfactory so far as shell fire is concerned provided they are protected from shell fragments.

Protection against shell fragments can be secured by burying communication lines a few inches.

Wires laid two or three feet from the surface in a narrow trench are, practically speaking, safe from damage by shell fragments.

Protection from direct fire hits can only be secured by burying cable below the penetration depth of artillery shell, therefore absolute protection is impracticable except that in the case of submarine cable absolute protection may at times be secured except at shore ends.

Protection as regards explosive force increases rapidly with the depth as the danger area of explosive force is, roughly, a cone.

No type of communication is safe against explosive force, but buried armored cable will stand a considerable explosive strain without damage.

The types of communication tested have the following order of merit as regards protection from shell fire: armored cable trenched, lead cable in ducts, any type of wire or cable in narrow deep open trench, wire laid on ground, wire on low poles, and wires on high poles.

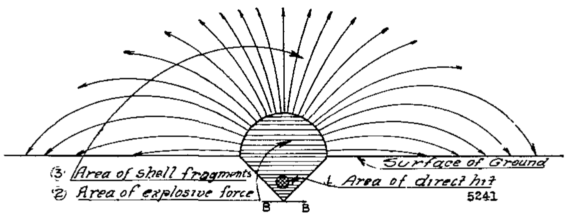


FIG. 3.

Where the course of the cable is known the armored cable trenched can be repaired with reasonable speed as the shell causing the damage will dig the hole necessary for repair. If the course of the cable is not known it may be difficult to decide which shell hole to investigate.

Protection from shell fire is not the only determining factor in the type of communication system.

Other factors are: initial cost, life, upkeep, insulation, capacity, resistance, ease of repair, and communication efficiency, which is a function of insulation, capacity, and resistance.

No. 19 gauge lead cable, paper insulated, will give satisfactory communication to points approximately four miles from the central storage battery, No. 22 gauge lead cable, paper insulated, about 2½ miles. No. 17 copper steel outside twisted pair is good for about 2¼ miles when new, but deteriorates rapidly.

The life of armored lead cable trenched may be taken as 20 years, that of good outside twisted pair as 2½ years.

Recommendations.—

Coast Artillery communications should preferably be armored lead cable, paper insulated, buried in the ground as deep as money available and local conditions permit, or laid on the bottom in protected water areas of sufficient depth.

A depth of two or three feet is considered economical in general for trenched armored cables.

Submarine cable should in general be laid in water area protected from enemy dragging operations and of sufficient depth to permit maneuvering of harbor vessels and cable steamers.

Each type of communication system has advantages and disadvantages which should be considered for any particular location. No type should be barred from consideration.

Two or three small cables routed differently should be provided rather than one large cable or several small cables together.

This may not be economical when a single installation is considered, however, when later installations are made the cables for the new installations may be so routed as to accomplish the above result. In this case it is advisable even at some expense to reassign pairs so that the failure of any one cable will not deprive any battery of its essential fire control lines.

Essential fire control lines are considered to be one pair to each essential base end station.

Where the cable system does not meet the above conditions, sufficient twisted pair field wire of ferrin circular loom cable (or both, in proper proportions) should be furnished each Coast Defense as a reserve supply to enable the above conditions to be met on the outbreak of hostilities.

Buried cable lines should be accurately mapped, should be located in a regular manner preferably in straight course and every effort should be made to make it easy to locate the course of the cable.

Mobile coast artillery is practically limited by considerations of weight and ease of installation to twisted pair and single conductor field wire, both rubber insulated. If well insulated wire is available it will often be advisable to bury it a few inches in shell swept areas.

2. Project No. 37, Subcaliber Ammunition for 12-Inch Mortars.—The development of more satisfactory ammunition for the 2.95 subcaliber gun was undertaken by the Ordnance Department at the request of the Coast Artillery Board. The solid projectile in general use at present gives a splash difficult to observe when the water is rough. To overcome this objectionable feature the Ordnance Department assembled an experimental lot of 2.95 subcaliber ammunition made up using 75-mm. shrapnel with time and percussion fuses. It was expected that the burst of the shrapnel on impact with water surface with the emission of smoke, would increase visibility. The danger from flying fragments is small as with the angle of fall in mortar subcaliber firing the balls are projected into the water.

497 rounds of this ammunition were furnished to the Coast Artillery Board for service test. The ammunition was fired with fuses set at "safe" at different times under different conditions of visibility, wind, and surface water conditions, viz., when water was very rough, moderately rough, and smooth. In order to establish a basis for comparison, service mortar subcaliber ammunition was fired at the same times and ranges. Height and widths of splashes were measured. In all cases the splashes made by the shrapnel were more visible than splashes of the service mortar subcaliber ammunition. In extremely rough water or in very hazy weather conditions the splashes of either shrapnel or service projectile will be difficult to see, but firing under such conditions is ordinarily neither necessary nor justified.

The Coast Artillery Board recommended that the shrapnel type of subcaliber ammunition be adopted for 12-inch mortars in place of the present service mortar subcaliber ammunition, provided the expense is not prohibitive.

3. Project No. 50, Antiaircraft Mounts for Caliber .30 Automatic Arms.—The matériel furnished for test included single and double mounts for machine guns, machine rifles, and automatic rifles.

The double mounts were designed to carry two machine guns or rifles. The use of the double mount was not recommended. The Board is of the opinion that the mounting of two guns on one tripod is of little tactical advantage. The difficulties in loading, aiming, and in reduction of stoppages are disadvantages which outweigh any advantage that may be obtained from unity of control.

A gun crew of strength at present authorized (one noncommissioned officer and five men) is sufficient to man one machine gun on a single mount, but a double mount requires one noncommissioned officer and eleven men.

In order to deliver an effective fire upon moving aerial targets, a large number of shots must be fired. This fire must be without intermission and should continue during the entire time that the target is within sight and range. The Board is therefore of the opinion, that the machine gun is the most effective small arm weapon for antiaircraft use. However, the mounts provided for the machine and automatic rifles were satisfactory and functioned properly for the arms for which they were designed.

The use of machine rifles and automatic rifles for antiaircraft work was not recommended.

The Board did not recommend the adoption of any of the machine gun mounts furnished for test, but recommended certain modifications and improvements, to be followed by further service test.

The tripod favored by the Board is one similar in design, but lighter, than that supplied with the .50 caliber machine gun. This tripod is pictured on pages 407 and 408 of the May, 1923, issue of the COAST ARTILLERY JOURNAL. Spread of legs and height of gun trunnions should be adjustable.

A simple trunnion and shaft bearing bent to allow 90° elevation should be made to fit the socket of the central staff of the tripod. This bracket should be similar to that at present furnished with .30 caliber antiaircraft machine gun tripods, allowing just sufficient clearance to fire at 90° elevation at all azimuths. The gun should then be mounted, using an adapter so that the trunnions will be in line with the force of recoil and as nearly as possible at the center of gravity of the gun when filled with water and full ammunition box attached.

4. Project No. 66, Rectangular Coordinate Slide Rule.—This device originated with Master Sergeant W. J. Helmer, C. A. C., on duty with the Sub-aqueous Sound Ranging Section, Fort H. G. Wright, N. Y. Its purpose is to convert polar coordinates, quickly, easily, and accurately to grid coordinates. The original design of the device was modified by the Coast Artillery Board and a slide rule was constructed at Fort Monroe in accordance with the modified design. The Coast Artillery Board found that the slide rule as constructed did not satisfy the conditions of the problem, i.e., to convert expeditiously, as well as accurately, the base end angles into rectilinear coordinates. The slide rule has been shipped to Fort H. G. Wright for further study, and possible modification. A complete description of the slide rule can be furnished on application.

5. Project No. 103, Mortar Range Board (M-1914).—Charts for aliquot part charges have been constructed and are available for distribution on application to the Coast Artillery Board. The primary function of this device is to serve as a mortar elevation board, it also permits the application of percentage corrections in changing zones. A description of the Mortar Range Board is given on page 114, Part IV, "Heavy Artillery Matériel."

6. Project No. 106, Fuze Setter Mountings for Antiaircraft Matériel.—The mountings received for test were found to be unsatisfactory. A new mounting was designed and submitted to the Ordnance Department with a request that several such mountings be manufactured for service test.

7. The following Training Regulations have been reviewed by the Board:

Project No. 108, Training Regulations No. 435-161, Identification of Aircraft.

Project No. 109, Training Regulations No. 435-331, Tactical Employment of Antiaircraft Searchlights.

Project No. 110, Training Regulations No. 435-30, Tactical Employment of Antiaircraft Artillery.

8. Project No. 114, Adjustment of Fire Against Moving Targets.—This subject has been considered by the Board and a report has been made to the Chief of Coast Artillery. The report of the Board recommends certain modifications of present methods of fire at marine targets and requests authority for publication of the report in COAST ARTILLERY JOURNAL for the purpose of stimulating interest in this subject throughout the Corps, and to invite correspondence with the Coast Artillery Board with suggestions for improvement of methods.

9. Project No. 119, Proposed New Model of Antiaircraft Searchlight (General Electric).—The General Electric Company has submitted plans and specifications for a 44-inch mobile, high intensity searchlight. The lamp is completely enclosed in contrast with the 60-inch open type at present in use. In connection with the study of the features of the proposed lamp it was found necessary to consider the antiaircraft searchlight problem in its entirety.

Our present lamps are mounted with one axis of rotation horizontal and the other vertical, hence when following a plane flying directly over the lamp at the instant the plane passes overhead, the searchlight must either be inverted or else rotated 180 degrees in azimuth.

The General Electric Company proposes to eliminate this difficulty by mounting one axis of rotation of the projector at 45° with the horizontal, this axis being the one that is at present vertical.

This method of mounting would eliminate the difficulty of following a plane as it passed over the zenith, but would make the same trouble occur at a point 45° from the zenith. This point could be varied, however, to suit conditions by moving the small truck in which the searchlight is ordinarily mounted.

The feature has no great practical advantage for Coast Artillery use as our mobile units have four searchlights per battery, and these lights are emplaced ordinarily about a thousand yards from the battery. Hence, only one light out of the four, at any given time, will be on a bad maneuver-point. With the method of mounting proposed by the General Electric Company, the result will be the same if the searchlights are located similarly, but the bad maneuver point can be shifted to the rear or any other desired direction instead of being directly overhead.

The 45° method of mounting might be of considerable advantage on naval vessels where all the lights must necessarily be mounted close together. When our present lamps are mounted near each other the bad maneuver point (their zenith) is the same for all, if they are on level ground. If the ground is sloping the effect of the General Electric mount is obtained with our present mounts.

So far as maneuverability is concerned a ball and socket mounting would give the best results, but probably would necessitate an objectionably high mount and would not lend itself to distant control, and could not be used near the horizon.

The type of mounting used for marine compasses would be almost as flexible as a ball and socket mounting but is apparently not suitable for searchlight work.

The opinion has been advanced that a 44-inch lamp will give better results than a 60-inch lamp due to the wide fringe of ineffective light accompanying the beam of the latter type lamps. A close analysis of this opinion indicates that it is true only when a good 44-inch lamp is being compared with a poor 60-inch lamp.

It is possible that even a good 60-inch lamp will give a wider fringe of ineffective light than a good 44-inch lamp, but present tables show that the illumination of a Sperry 44-inch lamp is only half that of a Sperry 60-inch lamp, and there is no reason to believe that General Electric lights would be materially better or worse than the Sperry lamps.

It is believed inadvisable to throw away half of the available illumination of the target if the problem can be met in some other way. The ineffective light on the fringe of the beam serves to illuminate moisture and dust particles in the beam and thus blanket the target to some extent, but even if all the ineffective light be suppressed, that portion of the effective part of the beam outside of the solid angle subtended by the target will cause the same difficulty. This is, in fact, the chief cause of this trouble, since effective illumination, being merely intense illumination, will illuminate air particles more intensively than ineffective illumination, which is merely dim light.

It is of course of value to suppress those portions of the beam that are not of sufficient intensity to carry effectively to the range of the target, but the best solution of the problem is a good distant control such that an operator of the light can control the movement of the light from a point several hundred feet from the lamp, rather than excessive refinement of the optical system of the lamp to secure absolute sharpness of the beam.

The present high intensity searchlights give a beam spread of about forty mils, hence the beam radius is about 12 feet at 600 feet, and therefore with the present type of mechanical control which places the observer about 12 feet from the lamp the operator has to look through the beam for almost its entire length even if he holds his target only slightly within the beam.

If we assume the target to be at a range of 15,000 feet, and a control system that places the operator at a distance of three hundred feet from the light the operator would only have to look through a few hundred feet of the beam if he held the target in the outer edge of the beam, and only thru half the length of the beam if he held the target in the center of the beam.

The Coast Artillery Board is of the opinion that a searchlight mount mechanically similar to our seacoast lights would be satisfactory. Having the lamp entirely enclosed for protection against wind and inclement weather conditions is a desirable feature. The present antiaircraft mount is unsatisfactory because it elevates and traverses in a jerky manner. This undesirable feature should be eliminated. The Board proposes to make a comparative test of the 44-inch enclosed lamp with the 60-inch open type of light. Future antiaircraft lights should be provided with distant control.

Until suitable listening apparatus is devised there will be no necessity for the distant control to be synchronous, although synchronous control is preferable if it can be furnished without excessive complications. By synchronous control is meant control similar to that now standard for the fixed defense lights, or a follow the pointer system accomplishing the same results.

As it appears that suitable listening apparatus may be developed in two or three years, it is, however, essential that the distant control furnished be capable of being modified at the minimum expense to some form of synchronous control.

The following scheme is one which would be satisfactory for the pilot light. (There is one pilot light in each platoon of 4 lights.)

A synchronous mechanical or electrical distant control having an accuracy of transmission of five mils, to operate pointers on the projector mounting so that the lamp may be controlled by a follow the pointer system.

For lights other than the pilot light the situation will be satisfactorily met if the projector is controlled in azimuth and elevation mechanically from a point 50 feet to one side of the lamp, and also arranged for hand control, by means of hand wheels and gearing at the lamp.

Antiaircraft lamps should have automatic feed, as automatic feed results in greater average beam intensity.

Employment of Heavy Artillery—Problem No. 12—A Solution

Major A assembles his staff and battery commanders and gives them the following verbal instructions.

The 2d Red Army, estimated strength three corps, has crossed the SUSQUEHANNA at WRIGHTSVILLE and MT WOLF, and is pushing our cavalry from YORK toward HANOVER JC.

Our 3d Army is at WESTMINSTER. The 1st and 2d Armies have been ordered to adjust their lines by refusing their right, to make contact with the 3d Army. The new zone of principal resistance of the 1st Army runs along LITTLES RUN—TWO TAVERNS—ASH GROVE SH—TOLL GATE— LITTLESTOWN—MT PLEASANT SH.

Our group moves at once to sidings at KEYMAR 7000 yards SW of TANEYTOWN. No railway rolling stock other than an Engineer Corps locomotive is available for this move. The motor transportation will move overland.

Battery Commanders will at once prepare their batteries for this move. All telephone lines will be taken up. Any dumped ammunition will be loaded on ammunition cars. Camouflage material capable of further use will be loaded on the mortars. Cooked rations will be prepared, and hot coffee issued at 4:30 PM. The service section locomotive will move cars from the Rear Echelon to NEW OXFORD at once. The cars and guns in position, including the gun at BRUSH RUN Siding will be moved at 2:30 PM. The armament train will be made up in NEW OXFORD, by the Bn R. R. Officer, in order from East to West, Hq Det, Ord cars, Btry B, Btry A, Bn Sect Serv. Btry, Switch Engine, and will be ready to leave that place at 5:00 PM.

The Communications Officer will have all battalion telephone lines taken up except one line to group commander, and one line to each battery. Those to the batteries will be taken up after the batteries move. Those to Group commander will be salvaged after this CP is closed at 4:00 PM.

Hq GpC AA will arrange for an Engineer Corps locomotive to handle the train out of NEW OXFORD. The Bn R R Officer will communicate with Hq GpC and ascertain definitely that the locomotive is to be available on time.

The Plans and Training Officer will command the motor convoy. The motor transportation will leave GRANITE HILL STA at 4:00 PM, the convoy forming in order, Bn Hq, Btry B, Btry A, Ord Det, Bn Sect Serv Btry, Med Det. Route:

via BONNEAUVILLE—WHITEHALL—PLEASANT HILL SH—TOLLGATE —LITTLESTOWN—OAK GROVE SH—WASHINGTON SH—TANEYTOWN —CRABSTER—KEYMAR.

Bn Hq will, with the exceptiou of men travelling with the store car, FC car and Power Plant, move in its motor transportation.

Members of the service battery who cannot go by truck will travel on the train.

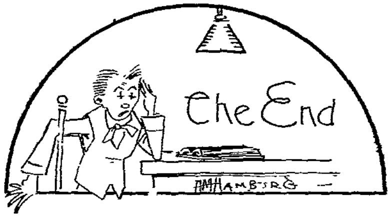
Five men from the Med Det will accompany the train. One officer and five men will go in the ambulance.

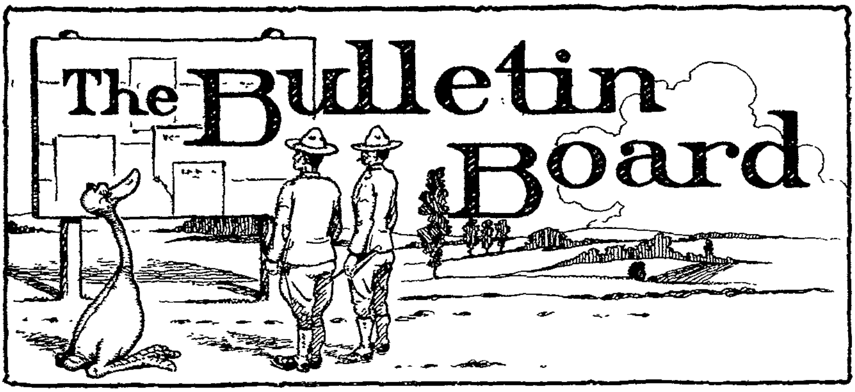
Battery personnel other than that riding in motor transportation will ride on the train.

The Intelligence Officer will start at 4:00 PM in motorcycle side car for KEYMAR reporting at 8 PM to GpC CP at P. O. for assignment of trackage and camp site.

Captain B (senior BC) will be in command of the train, which will be controlled by Engineers after leaving NEW OXFORD.

I will leave NEW OXFORD at 5:00 PM in the 5-passenger car for KEYMAR. Upon arrival, train and convoy commanders report to me at P. O. unless they receive message from me to do otherwise in the meantime.



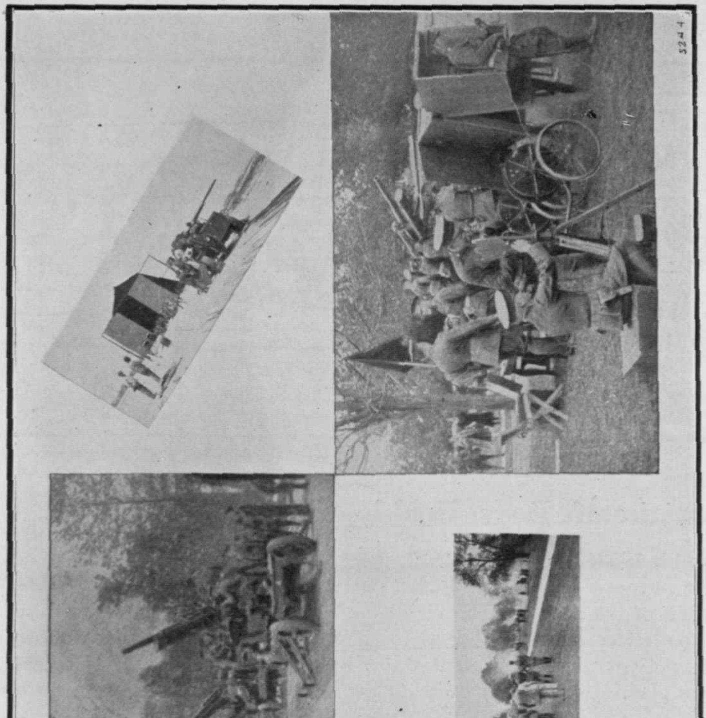


The Antiaircraft Days, Held by the 62d Artillery, (A. A.)

On May 12, 1923, and June 2, 1923, the 62nd Artillery (AA), held demonstrations for the purpose of assembling all Coast Artillery Antiaircraft officers of the three branches of the Army in the vicinity of New York City, in order that they might become better acquainted, and to show them by lectures, demonstrations, drills and target practice the present status of antiaircraft defense. Recreational features were also introduced in order to provide a pleasant relaxation from civil vocations.

The first of the two Antiaircraft Days was held at Fort Totten, and touched the subject from a theoretical and practical standpoint. At 2:00 P.M. the assembled officers were welcomed by Brig. General H. A. Drum, the Commanding General of the 2nd Coast Artillery District, who is the originator of the Antiaircraft and Coast Defense Day idea, and were told of the present status of the Army, its aims, plans, and limitations.

Following General Drum came several short lectures on antiaircraft defense, the tactical organization of an antiaircraft regiment and a discussion of the part played by the antiaircraft machine guns in France. During the last few minutes of the concluding lecture a plane circled the parade ground and dropped a message to the Commanding Officer, 62nd Artillery, which was in substance as follows: "Hostile bombing squadron approaching Rockaway flying North." *Call to Arms* was sounded, the 62nd Artillery passed by in march order and took up defensive positions about the parade ground to repel the expected attack. Regimental C.P., message center, radio station and a complete system of communications were installed in a few minutes. Liaison was established with the lower units, each completely installed, or where shortage of personnel demanded, simulated. Appropriate signs identified each element so that, as the visiting officers moved about the parade ground inspecting the matériel, a minimum of verbal explanations was required. A full series of reports and orders for action were received and sent and when at 3:50 P.M. a squadron of six D.H. 4's appeared, the machine guns and antiaircraft guns at once opened fire with blank ammunition, repelling the invaders with heavy losses. As the last plane disappeared the command "March Order" was given and exactly sixteen minutes later the parade ground was cleared and the regiment formed as infantry on the far side from the spectators.



SEEN AT THE 62ND ARTILLERY'S ANTIAIRCRAFT DAYS AT FORT TOTTEN AND FORT TILDEN

At a given signal, blouses, belts, and hats were removed and laid on the ground and the regiment as a unit double timed across the intervening space, halted and extended for mass calisthenics to music.

This formation seemed to be especially interesting to the moving picture men who took many feet of film from half a dozen view points. Again by signal the regiment assembled, moved at a double time back to the original position, put on equipment and formed by battalions for review by General Drum. Battery B, the original Alexander Hamilton Battery, whose history dates back to 1776, received the colors from the Colonel's quarters and escorted them to their place in line. The review concluded, the regiment formed for evening parade and in the cool spring twilight all stood motionless at attention while the beautiful garrison flag slowly floated down to the strains of the National Anthem. The troops marched by and returned to barracks; the visitors adjourned to a buffet supper served in the Officers' Club. Searchlight drill had been scheduled for the early evening but rain prevented and the gap between supper and the hop was spent renewing old friendships and recalling the days "over there." The dance in the ball room in the Officers' Club was the largest ever held at Fort Totten and judging from the number who stayed straight through to the end it is believed that the music of the 62nd Artillery Band orchestra was thoroughly enjoyed.

The second Day was held on June 2nd at Fort Tilden in order that service firing could be witnessed by the visiting officers. The latter were welcomed as before and the day's schedule explained, lectures on fire control apparatus, and system, and on the tactical use of searchlights preceded the first firing which was at target bursts. A rapidly thickening haze prevented any gun-firing at ordinary altitudes and after a series of hydrogen balloons had been broken by the machine guns, the greater part of the afternoon was given over to exhibition drills and detailed explanation of the various elements of the gun and searchlight batteries.

As a concluding feature, with fuses cut short, both gun batteries firing simultaneously built a beautiful pattern about a low target burst, shots going at even four second intervals with the regularity of clock work. This was so well received by the spectators that it was successfully repeated.

In spite of the cold season numbers of the visitors availed themselves of the opportunity to enter the high surf which had been breaking all day along the white sand beach. At six o'clock supper was served in the troop mess hall and at its conclusion, the haze having become more dense than ever, the night firing at illuminated targets was cancelled and the day concluded.

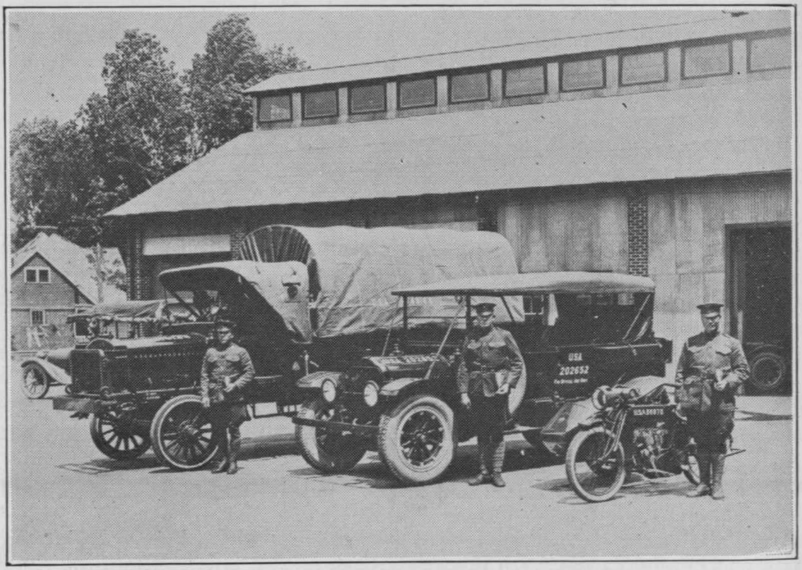
It is felt that in spite of the limitations and disappointments imposed by adverse weather conditions, the interest of the Reserve and National Guard Officers was quickened; that they were made to feel the importance of their place in our Army, and that the *esprit-de-corps* and general morale of the 62nd itself, by virtue of the responsibility successfully shouldered, was stimulated and strengthened.

C. A. School Wins in 3d Corps Area M. T. Show

The 3d Corps Area staged a military Tournament in the new Baltimore Stadium on June 2, 1923. One of the features of the Tournament was a Motor Transport Show where all special and standard type motor vehicles used in the Army were on display. Prizes were awarded for the best special type vehicle and for the best standard type vehicle. All organizations within the Corps Area equipped with motor transportation had entries in the show. These included besides the Coast Artillery, the Quartermaster Corps, Air Service, Chemical Warfare Service, Ordnance Department, Medical Department, Infantry, and Signal Corps.

The Coast Artillery School had three vehicles in the show and each entry took first prize in its class.

A White Staff Car driven by Pvt. Tyler Bowling, C. A. S. Det., took the 1st prize for special type vehicles. A Class B Truck driven by Pvt. Leon M. Sherman, C. A. S. Det., was adjudged the best Class B Truck and a motorcycle, with



side car, driven by Tech. Sgt. B. L. Bingham, C. A. S. Det., was awarded first prize in the motorcycle contest.

The judging of all types of vehicles was based on appearance and mechanical condition of the vehicles and on the appearance and knowledge of the drivers.

Massachusetts Coast Artillery Dedicated Two Batteries

On Monday evening, June 11, 1923, the Coast Artillery Corps, Massachusetts National Guard conducted a unique ceremony at the South Armory, Irvington Street, Boston, to dedicate armory batteries in honor of Major F. Holbrook and Captain E. F. Chase. The regimental formation was commanded by Colonel B. B. Shedd, C. A. C., M. N. G., who tendered a review of the command to Brigadier General Mark L. Hersey, U. S. A., commanding the First Coast Artillery District, who delivered the dedicatory address of the occasion.

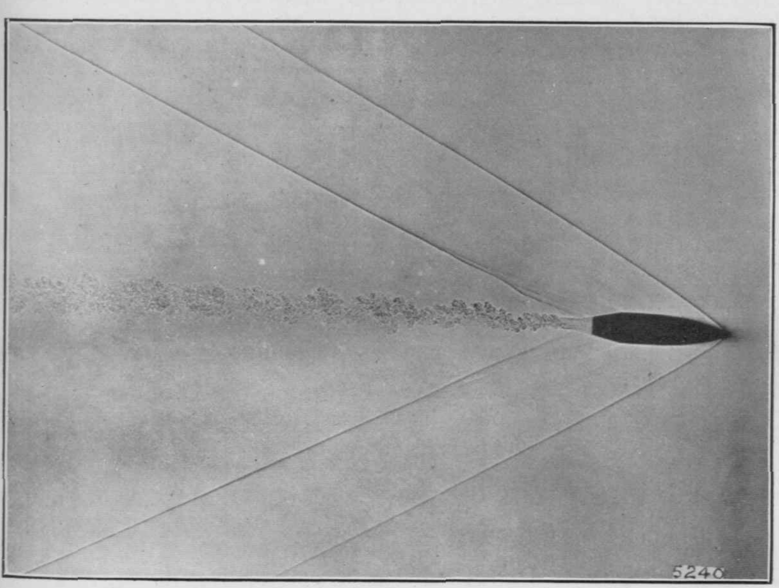
Fort Ruger Wins Two Competition Banners

On May 13 Fort Ruger won the Hawaiian Coast Artillery District Guard Banner, as against all the other posts in the Hawaiian Coast Artillery District, in the Guard Competition held during March of this year. The guard which won the competition was a mixed guard, consisting of men from every organization in the post with Captain Henry Linsert, C. A. C., commanding Battery F, 55th Artillery, as the Officer of the Day.

Fort Ruger also holds the competition banner for the best Mess in the Hawaiian Coast Artillery District, the Banner being won by Battery E, 55th Artillery. The particular credit for the winning of this competition goes to Sergeant Frank L. Jackson, the Mess Sergeant of Battery E.

The Boat Tail Bullet in Flight

2nd Lieutenant Philip P. Quayle, O. R. C., has kindly sent to the JOURNAL a photograph, reproduced herewith, of a .30 caliber boat bullet in flight, at a velocity of about 2600 feet per second. This photograph clearly shows the sound waves given off from both the nose and the base of the bullet as well as the appearance of the wake.



Centennial Celebration at Fort Monroe

On June 29th the hundredth anniversary of the occupation of Fort Monroe, Va., by troops of the Regular Army was celebrated with appropriate ceremonies. Invitations had been extended to prominent civil and military personages as well as to the general public of the Peninsula and a large number turned out for the exercises.

The program opened at 8:00 A.M. with a review of troops, including the Fixed Defense Battalion. the 61st Artillery Battalion (A.A.) and the units of the R. O. T. C. and C. M. T. C. encamped at the Fort. Following the review the visitors were conducted through the summer training camps where about five hundred young men were under instruction. The transportation of the 61st Artillery Battalion (A.A.) and of the Coast Artillery School then passed in review, its splendid condition bringing well merited applause from the spectators. After the review an inspection of the Coast Artillery School and the Library was made.

At 10 A.M. the visitors and the entire command assembled at the Liberty Theatre which was specially decorated for the occasion. Col. J. F. Howell, commanding the Coast Defenses of Chesapeake Bay, made the address of welcome and Brigadier General W. R. Smith, commanding the Third Artillery District, gave an outline of the history of the fort from its earliest days to the present. Hon. Harry R. Houston, of Hampton, formerly Speaker of the Virginia House of Delegates, spoke of the value to the country of the R. O. T. C. and the C. M. T. C., and Congressman S. O. Bland, elaborating upon this topic declared that ther would be no danger of Prussianism in the United States so long as the peopl were made acquainted with the Army thru the citizens' training camps. H· stated that he believed education to be the greatest single factor in modern life

Mrs. A. F. Ryan, formerly prima donna of the Opera Comique of Paris, ren dered a selection from "Thais" and the entire audience, led by Master Sergean John D. Jones, sang "America" and "the Red, White and Blue." "The Sta Spangled Banner" sung by Mrs. Ryan, and benediction by Chaplain Easter· brook concluded the program.

In the afternoon a thrilling baseball game took place between the Antiaircraf and Fixed Defense Battalions, the Antiaircraft team winning 11 to 6. A receptior was held at the Fort Monroe Club at five o'clock and the Fourth Band gave a concert on the Waterfront at seven. The entire program was a great success and much credit is due Colonel Howell who arranged the affair.

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BOOK REVIEWS

MATHEMATICS

Calculus and Graphs. By L. M. Passano. The Macmillan Co. New York. 1921. 5" x 7½". 167 pp.

This brief course in the elements of calculus assumes a knowledge of elementary algebra and trigonometry. No knowledge of analytic geometry is required on the part of students using this text. This is a pleasant departure—one that will be welcomed by those who feel that such a course in the elements of calculus is not only more useful, but also more interesting and simple than a first course in analytic geometry.

In the first chapter the idea of coordinate axes and their use in the graphical representation and study of simple algebraic and transcendental functions is introduced and followed throughout the book. The student becomes familiar with the fundamentals of analytic geometry, and becomes acquainted with the forms and equations of simple curves without having made a detailed study of their properties. Thus he acquires the knowledge of analytic geometry essential to the study of elementary calculus.

The author's purpose in writing this book is primarily to make the elements of the calculus directly and familiarly available to students of physics, chemistry and other sciences and for the use of those who wish an elementary knowledge of calculus for its cultural value.

Differential Equations. By H. Bateman. Longmans, Green and Co. New York. 1918. 5¾" x 9". 306 pp. Price, $3.25.

In the preparation of this text-book on differential equations, the author had in mind the needs of students pursuing a first course and those interested more in physical mathematics than in the developments of differential geometry and the theory of functions. The material included is more in the nature of a practical course in the solution of differential equations. This is emphasized by the unusually large number of examples, many of them illustrative, scattered throughout the text.

Beginning with Dr. Forsyth who is acknowledged as the pioneer in the publication of text-books on differential equations in English, the subject has gradually been developed and has grown so rapidly in recent years that it is now somewhat difficult to do justice to all branches of the subject in a single volume. In this book the author gives not only the common methods, but integrating factors and geometrical applications including singular solutions. Chapters are devoted to differential equations with particular solutions of a specified type; partial differential equations; total differential equations; partial differential equations of the second order; integration in series; the solution of linear differential equations by means of definite integrals; and mechanical integration of differential equations.

An Elementary Treatise on Differential Equations and Their Application. By H. T. H. Piaggio. The Open Court Publishing Co. Chicago. 1921. 5½″ x 8¾″. 242 pp.

This elementary treatise on differential equations and their applications, an addition to Bell's Mathematical Series, Advanced Section, originally published in 1920 and recently reprinted, constitutes a very readable treatment of the subject.

The handling of the subject-matter is such as to make it suitable for beginners, and at the same time serves to point out the different directions in which it may be developed. The arrangement is in as simple a form as possible, the greater part of the text and examples in the body of the work being easy. The miscellaneous examples at the end of the various chapters are slightly harder, and the 115 examples at the end of the book are of much greater difficulty. An appendix gives suggestions for further reading. The number of examples solved and suggested to the student is large, the answers to the unworked ones appearing at the end of the volume.

History of The Theory of Numbers. Volume III—Quadratic and Higher Forms. By Leonard E. Dickson. Carnegie Institution. Washington. 1923. 6¾″ x 10″. 308 pp. Price, $3.25.

It would be highly presumptuous for any but one of the most noted mathematicians to examine critically the concluding volume of "this extensive and intricate branch of mathematics." And we are not a noted mathematician—just an artilleryman whose avocation is mathematics.

The amateur may form some idea of the time and attention necessary for the production of such a work as this, when he considers that G. H. Cresse "devoted five years to the preparation of the report in Chapter VI on the difficult subject of the number of classes of binary quadratic forms, which involves many branches of pure mathematics."

That Professor Dickson is capable of such a task as this history of the theory of numbers, is generally acknowledged, but the overwhelming success of his project must be a real pleasure for him and his many admirers.

No student of the theory of numbers should fail to study carefully this work which aims to give "an adequate account of the entire literature of the theory of numbers."

Volume I was published in 1919 and Volume II in 1920. A supplement will be published later.

Introduction to the Calculus. By William F. Osgood. The Macmillan Co. New York. 1922. 5″ x 7½″. 456 pp. Price, $2.90.

In this introduction to the calculus Professor Osgood presents a revision of his "First Course in the Differential and Integral Calculus." His object is to set forth the application of the calculus to problems of geometry and physics of the first order of importance, and to make clear the thought which underlies the calculus.

The author, realizing that the student who has no technical knowledge o physics can understand the simplest physical concepts when clearly presented t him, takes great care each time that a new physical notion has been introduced t say exactly what is meant, and then shows how mathematics applies to the par ticular situation in hand.

The book is intended for the engineer or the physicist and for the student o pure mathematics.

Plane Geometry. By C. Addison Willis. P. Blackiston's Son and Co. Phila 1922. 5½" x 7¾". 301 pp. 473 Ill. Price, $1.32.

Geometry! The grand old science. The twin sister to analysis. How many of us in our student days had the remotest idea of the important part this branch of mathematics has had in the development of civilization.

This author does not hesitate to add yet another volume to the innumerable list of texts on geometry. His book represents the experience of a quarter of a century of geometry teaching. The philosophy and methods embodied in it are those of his own class-room. He believes that a pupil learns more of the subject as he presents it, and he is certain that every pupil who is taught by his method under the guidance of a teacher who is himself interested in the subject, becomes inspired to learn and is willing to work to learn.

The text is so arranged that it may be used in various ways; as a short course a laboratory course; and as a complete course. There is a wealth of additional theorems, exercises and review exercises, sufficient to enable the teacher to vary his class assignments from term to term, for many years.

Plane Trigonometry with Practical Applications. By Leonard E. Dickson. Benj. H. Sanborn and Co. New York. 1922. 6¼" x 8¾". 224 pp. Price, $1.52.

In these prolific days of books on elementary mathematics, it is a real pleasure to come across one that is different. Instead of the hackneyed and dull problems calling for the solution of a triangle in which certain sides and angles are given, the problems proposed in this text-book are real and reflect some activity of actual life. Almost from the very beginning of the book applications of trigonometry to the elementary parts of surveying and navigation, as well as to composition of forces, are introduced.

The book includes chapters on logarithms and the slide rule; navigation and land surveying. Among the tables, which are given to four places and serve for all practical purposes, is a traverse table, which in addition to its use in navigation and surveying is a time saver in relieving the monotony of logarithmic computations.

The subject-matter is handled with great discretion, emphasis being placed on the practical applications, the illustrative examples and the proposed problems—the whole executed in the most admirable manner.

Practical Mathematics for Home Study. By Claude I. Palmer. McGraw-Hill Book Co. New York. 1919. 4¾" x 8". 493 pp.

In 1912 the author undertook to do just one thing and this he did effectively. He produced a series of four volumes on practical mathematics arranged for classroom use for men engaged in practical pursuits. The needs of these men who attended evening classes were carefully studied and as a result the matter presented fulfilled their requirements, being of an intensely practical nature.

Based on his fifteen years teaching in the evening school at the Armour Institute of Technology, Professor Palmer presents a revision of his original work this time in one volume, to meet the needs for home study. The subject-matter includes all that is in the four volumes, being the essentials of arithmetic, geometry, algebra and trigonometry, and in addition a few new topics together with many solutions of exercises, and suggestions that make the text more suitable for home study.

The author hopes that his book will find a place in the library of the man who applies elementary mathematics and who wishes occasionally to brush up on his mathematics.

Rapid Arithmetic. By T. O'Conor Sloane. D. Van Nostrand Co. New York. 1922. 5" x 7¾". 190 pp.

How to make arithmetic interesting is the pleasant task Dr. Sloane has set himself. He fully justifies the title of his book by presenting in an unusually interesting manner a dozen or more methods of adding as well as a number of ways of applying the other three primary rules.

He shows how easy it is to carry the multiplication table from twelve times on to at least towards twenty times, and demonstrates fully that it is within the reach of anyone to add up two columns simultaneously.

He considers not only the four primary rules, but devotes a chapter each to fractions, the decimal point, interest and discount, powers of numbers, exponents and squaring the circle.

Not only is this book of Dr. Sloane's a supplement to the ordinary text book of arithmetic, but a practical application in real work, for by applying the methods to be found in its pages a greater command of arithmetical operations will be acquired and quick ways of calculating will result.

Slide-Rule Notes. By H. C. Dunlop and C. S. Jackson. Longmans, Green and Co. New York. 1913. 4¾" x 7½". 127 pp. Price, $1.00.

Although not a recent publication these "Slide-Rule Notes" by Colonel H. C. Dunlop, late professor of gunnery, Ordnance College, Woolwich, and C. S. Jackson, one of the general editors of Longman's Modern Mathematical Series, are timely and of real value to the student, engineer, business man and Army officer.

The authors devote the first chapter to an "Elementary Explanation," the aim being to help the non-mathematical student to understand the principle of the Slide-Rule. After a brief exposition of logarithms, logarithmic scales are taken up showing the operations required for multiplication and division, squares and square roots, cubes and cube roots. Then follow chapters on the construction operation and use of trigonometrical and logarithmic scales and the central scale. Plotting curves from equations and the arrangement of the work in developing the scales are considered in a chapter.

The notes are illustrated throughout with diagrams and solutions of problems, each chapter being followed by well chosen examples.

Supervised Study in Mathematics and Science. By S. Clayton Sumner. The Macmillan Co. New York. 1922. 5" x 7½". 251 pp. Price, $1.40.

By means of outlines of the successive stages in the development of the subjects and type lessons, the author in simple language presents his ideas of supervised study in mathematics and science. The lessons can only be suggestive but the material included serves to aid in the planning of others. His aim in the preparation of this volume in the Supervised Study Series, edited by Professor Alfred L. Hall-Quest, was to write a book that would be of explicit and direct value to the teacher who is striving to teach his students how to study and ho' to learn.

The author is a firm believer in supervised study, and while it is not a panace for all pedagogical ills, it is valuable and promises much for the future as progres is made in the proficiency of its administration.

Unified Mathematics. By Louis C. Karpinski, Harry Y. Benedict and John C Calhoun. D. C. Heath and Co. New York. 1922. 5" x 7½". 522 pp. Ill

We are indebted to these three professors of mathematics for this excellen textbook on elementary mathematics. It is the result of a clear cut convictioı that mathematics cannot be artificially divided into components with separat labels, as has been the habit. It aims to show the essential unity and harmon and interplay between the two great fields into which mathematics may properl be divided, namely, analysis and geometry. An important feature is the abundant use of illustrations drawn from fields with which the average student has had contact. These illustrations the authors maintain are extremely important for mathematics is not only a mental discipline, but a powerful tool of science playing a wonderful part in the development of civilization.

The material includes college algebra, trigonometry and analytical geometry. The authors feel that if the student has mastered the text he will have at the same time, with no great effort, have acquired a real appreciation of the mathematical problems of physics, engineering, statistics, and science in general.

PHYSICS

A Concise Physics for Engineering Students. By John E. Hoyt. P. Blakiston's Son and Co. Philadelphia. 1922. 5½" x 7¾". 385 pp. Price, $2.50.

This text-book of physics was written to fill a long felt want for a concise text for engineering students. It was the author's aim to write a text-book that could be studied with profit by the student who has had a high school course in physics, but the work has been so planned that one who has not pursued such a course will not be seriously handicapped by that fact. The text leads directly to the advanced engineering courses, and is illustrated by practical problems to show the student that a knowledge of physics is fundamental in an engineering course.

The characteristic features of Dr. Hoyt's text are the conciseness of treatment of fundamental principles, the solution of many illustrative problems, and the large number of practical problems for solution by the student. One of the interesting and perhaps the most valuable feature is the attention which the author directs, all through the text, to the fact that all formulas are merely mathematical expressions of definitions or laws, true under certain stated conditions.

Elementary Mechanics. Prepared by the Department of Mathematics of the United States Naval Academy. U. S. N. A., Annapolis. 1922. 5" x 7½". 352 pp. Price, $3.95.

This revised edition was deemed necessary to clarify the explanations in certain parts and to correct errors. The text was prepared as a short course, the aim being to present the fundamental principles of mechanics in a simple manner and to give a rigorous discussion of each topic to the extent that it is treated.

It is clearly impossible in these short notices to give any just idea of the breadth and scope of such a volume. An idea of the arrangement may be had from the following chapter headings: vectors; statics of a particle; forces acting on a rigid body, statics of a rigid body; center of gravity and moment of inertia, fluid pressure; deformable bodies, rectilinear motion; work and energy; curvilinear motion; and dynamics of a rigid body. Many new problems have been added making a total of 647. The authors are to be commended for producing a textbook which is especially notable for its simplicity and clearness.

Essentials of Modern Physics. By Charles E. Dull. Henry Holt and Co. New York. 1922. 5″ x 7½″. 525 pp. Price, $1.72.

Notwithstanding the fact that we can see and feel the stupendous power of nature—how she manifests herself in these physical and chemical forces forever present about—us the task of presenting the merest essentials of these sciences to students of high school age, has been fraught with real difficulties.

The author of this text, realizing the importance of physics in developing the reasoning powers, in cultivating the uncommon faculty of common sense, planned and executed his book with the student's point of view in mind. For instance, the usual formulas, meaningless to the student on first glance and forever after studiously avoided, are listed in the appendix, and an effort made to develop the analytical method. The author's plan consists in using familiar illustrations to introduce each principle to be studied. The principles are then clearly and concisely stated and finally clinched by an extended use of practical applications.

Of worthy attention is the chapter devoted to the automobile, and the method indicated to show the study of the automobile can be used to review the whole subject of physics. For instance the transmission system may be studied in connection with gear wheels in mechanics, the radiation system with heat distribution, the clutch, brakes and non-skid tires with friction, the carburetor with the gas engine, and the non-glare lenses under diffusion of light. Or the automobile may be considered as consisting of three parts: (a) the power plant; (b) the chassis, or running gears; and (c) the body.

Gravitation versus Relativity. By Charles L. Poor. G. P. Putnam's Sons. New York. 1922. 5½″ x 8¼″. 277 pp. 35 Ill. 6 Tables.

According to Einstein's general theory of relativity, gravitation instead of being some mysterious force is simply a property of space. This involves the assumption that space is curved, that our universe is finite.

Since Einstein "enunciated" his Special Theory of Relativity that upset our ideas of absolute time and space, and more particularly since the World war, volumes after volumes have been published purporting to give a popular interpretation of this theory, some few opposing the theory. The volume before us is doubly significant for its author is an authority on Celestial Mechanics and it is claimed to be "a non-technical explanation of the fundamental principles of gravitational astronomy and a critical examination of the astronomical evidence cited as proof of the Generalized Theory of Relativity."

It is not within the province of such a short notice as this to indicate the arguments used by the author in submitting the astronomical proofs of the Relativity Theory to a critical examination and discussion. It may be said that although there is an absence of bewildering technicalities and heavy theorizing the validity of these proofs cannot be passed upon by one who is totally unfamiliar with the facts and methods of astronomical research. The author reminds us however, that it is not necessary that one know all the complicated details of planetary motion, nor be familiar with all the methods of determining the size, shape and motions of Mercury, but it is essential for one who would fairly judge the evidence, to know the fundamental methods and approximations used in determining the motion of a planet about the Sun.

This important contribution to this world controversy is prefaced with an essay by Thomas C. Chamberlin, Emeritus Professor of Geology, in the University of Chicago. .

The author is professor of Celestial Mechanics in Columbia University and author of "The Solar System," "Nautical Science," and "Simplified Navigation."

Outlines of Physics. By Charles C. Bidwell. The Comstock Pub. Co. Ithica, N. Y. 1922. 5½" x 8". 104 pp. Price, $2.50.

The sub-title of this little volume is fairly indicative of the subject-matter contained therein. A concise discussion of the laws and relationships of physics and their mathematical expression. The author tells us that his book is a development from notes used for several years in mimeograph form by students of engineering and chemistry at Cornell University as a basis of a second course in physics. It is designed for those students who have completed an introductory course in college physics, and have had a first course in differential and integral calculus.

The author's aim in preparing this text was to bridge the gap between the introductory descriptive texts and the more advanced mathematical treatises on special topics, by a work the purpose of which is to study the fundamental laws of physics and to show how these laws are expressed in mathematical form.

Philosophy and the New Physics. By Louis Rougier, English translation by Morton Masius. P. Blackiston's Son and Co. Philadelphia. 1921. 4¾" x 7½". 159 pp. Price, $1.75.

This little work—an essay on the relativity theory and the theory of quanta—written originally in French by Professor Rougier, and translated into English by Professor Masius of the Worcester Polytechnic Institute, is an attempt to interpret in the space of a 100-odd pages the new advances in physics. It is the author's hope that it will be of great interest to the physicists who are so occupied with their special problems, as to give little attention to matters of more general philosophial interest, and to philosophers whose knowledge of science does not enable them to discuss and fruitfully criticise the work of the physicist.

Among the headings under which this essay on the manner in which the older dualistic view of matter and energy has been superseded by the newer idea of the merging of these two concepts into each other, are, "The Electron Theory of Matter," "The Inertia of Energy," "The Weight of Energy," and "The Structure of Energy."

Questions and Problems in Physics. By Floyd L. Darrow. Harcourt, Brace and Co. New York. 1922. 5¼" x 7¾". 231 pp. Price, 80 cents.

In this collection of questions and problems in physics, Mr. Darrow expresses his appreciation of the need which every earnest teacher of physics recognizes; for regular assignments of well selected problems, if his pupils are to master the subject. His attitude, common to most teachers, is that in no other way can the fundamental principles of this, the most important of the elementary sciences, be instilled. This requirement the author meets by presenting not only purposeful problems in abundance, but a most thorough and logical developmmet of the subject by thought-provoking questions as well. To make the student think as he studies in the purpose of the book.

For review and supplementary work, classified lists of the examinations of the College Board, and those of the Regents of the State of New York, for the last seven years have been included. Tables for use in obtaining the necessary constants for the solution of problems are added for the convenience of the student.