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FOREWORD

What is a mine? What is a torpedo? Are these naval weapons as much of a threat today as they were in past wars? How are these "underwater robots" built, weapons capable of destroying the largest vessels? This book will attempt to discuss all of these questions.

During World War II most of the ships sunk or destroyed were victims of mines or torpedoes. The high military effectiveness of mines and torpedoes is explained by the fact that on detonation they damaged the underwater portion of the ship, the least protected portion of the vessel.

The successful use by submarines, surface ships and aircraft during WWII of electric and homing torpedoes, as well as many types of influence mines, called for the application of extreme measures in order to protect ships from these weapons. Such measures included demagnetization of the hulls, reducing the noise level, and the use of various kinds of screens for the ships, and the like. However, the advent of new and more powerful models of mines and torpedoes invariably outstripped the rates of development of the means devised to counter them.

The process of improvement of mines and torpedoes did not stop with the end of the war. During the post-war period there was a qualitative jump in the development of underwater weapons in consequence of the achievements made in science and technology. Also, changes were made in their tactical application.

Along with the dramatic development of jet propelled guided missiles great improvements were made in the design of mines and torpedoes.

The major capitalistic powers are concentrating their scientific research in this sphere, making extensive use of new kinds of missiles, as well as the application of new ideas in the fields of electronics and atomic physics. As a result of all these things the range and speed of torpedoes has been increased dramatically; the destructive charges carried by torpedoes and mines have also been increased greatly. New and more /4 effective homing systems have been perfected, and influence firing mechanisms have been developed which react to different physical fields surrounding submarines and surface ships.

Apologists for war attribute great importance to the naval forces, especially to the submarine arm, in their striving to gain world domination, and they devote a great amount of attention to the development of mines and torpedoes as the weapons to be used against ships.

Judging from the information passed on by the foreign press, the torpedo, as an antisubmarine weapon, is regarded as a very valuable tactical device when combined with its own rocket carrier. Torpedoes of this kind can be launched from submarines and surface vessels alike. These torpedoes travel a great distance along their air trajectory after being launched and, upon entering the water in the target area, continue on to search for and destroy an enemy submarine at any depth.

The modern mine is an automatically operating underwater weapon.

In commenting on the capability of a mine to function over a prolonged period of time under concealment in the worst kind of weather and bearing in mind that modern mines are controlled, foreign military theoreticians are planning to set their mines beforehand to have their mine fields in a combat ready state with the commencement of military operations; the mines will be activated from the land by means of remote controls.

It should be mentioned that the achievements in the development of mines and torpedoes, as described in the foreign press, are oftentimes intended as publicity stunts. The authors of these books strive to substitute the desired for the actual.

The experiences of WWII and the Great Patriotic War ~~insistently~~ point to the necessity for a complete study of mines and torpedoes and of the methods to be used for combatting them. Hence, one of the tasks of this book is to assist the reader in problems of this kind.

This book has been written by the authors ~~who~~ have made extensive use of foreign literature relating to questions dealing with mines and torpedoes. Part I of the book was written by Yu. M. Baginskiy, and part [illegible] the effort of V. P. Beloshitskiy. The authors express their gr[illegible] to G. M. Lebedskiy for his invaluable advice in the writing of t[illegible]ook.

PART I

THE MINE -- AN AUTOMATIC UNDERWATER WEAPON

During the war the mine was referred to as a "dangerous, invisible weapon." Actually, mines are underwater automatic devices operating under conditions of concealment. They lie in wait for the enemy in all kinds of weather, day and night, as though hiding in an ambuscade. As soon as the submarine or surface vessel approaches the mine closely or comes in contact with it the powerful charge inside the mine explodes. Detonation occurs the instant the target enters the destructive area of the charge (fig. 1). /5

On exploding the mine affects the most vulnerable portion of the ship -- the underwater portion -- and ruptures the hull. The water pours into the ship, putting the engines and mechanisms out of operation. The largest of modern ships can be destroyed by such action.

Mines are used for the defense of a nation's coastal boundaries and for active operations in enemy waters against submarines, surface craft, and merchant shipping.

They are planted in the most probable areas of movement of enemy ships, along his coastline, in narrow straits, channels, the open sea, and on the high seas in the important lines of communication. When that occurs the vast oceanic space becomes dangerous to navigation. Where shipping lanes formerly were free of shoals, reefs, and underwater rocks artificial underwater barriers suddenly appeared -- mine fields that spelled destruction to shipping.

The mine menace keeps the crew of a ship on the alert. Fear of mines can sometimes occasion greater losses and damage than the sinking of a ship. The threat posed by mines calls for the expenditure of great amounts of money for the purpose of seeking them out and destroying them; it diverts large numbers of men for the dangerous and laborious work of neutralizing them, interrupts planned military operations, and forces ships to follow circuitous courses to avoid contact with mines.

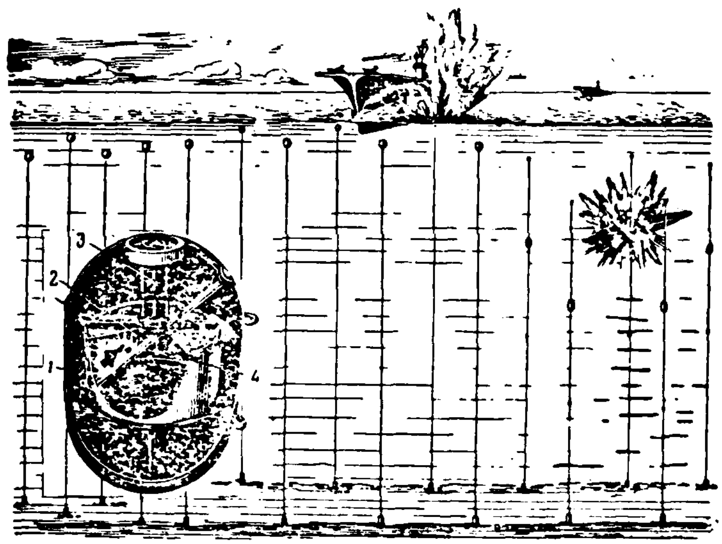

Fig. 1. A mine field. The hull of a mechanically fired contact mine in cross section: 1. Mine shell; 2. chamber for explosive charge; 3. automatic firing mechanism; 4. exploder device.

Use of large numbers of mines of various kinds can very dramatically complicate and change a situation in a military theatre of operations.

The tactical properties of a mine are such as to permit the solution of a very broad range of tasks in the war at sea when it is employed simultaneously with other means of modern armed warfare.

BRIEF HISTORY

The idea of launching an underwater attack goes back to the dawn of development of marine shipping. The first underwater attack was carried out in a naval engagement in which one vessel attempted to ram another. When ships were equipped with artillery they acquired the capability of firing upon the enemy by maneuvering from a distance. But in those remote times the artillery weapon was nothing but a catapult device which used heavy rocks as its missiles. This type of artillery could attack only the above water portion of the ship. Despite the great damage inflicted upon the ship it could remain afloat because the underwater part of the craft remained inaccessible to damage. It therefore became clear that the most successful kind of attack would be one directed at the part beneath the water surface; any damage to this portion of the hull was dangerous because it could cause the ship to sink. /7

With the advent of gunpowder the idea occurred that a charge of powder could be placed in a waterproof container, moved under the water, and applied to the bottom of the enemy ship; the charge would then be exploded. This kind of underwater explosion could inflict great damage to a ship, causing it to sink.

However, the first attempts to develop a weapon with a powerful explosive force which might operate surreptitiously under water proved unsuccessful despite the many methods of its application that had been proposed.

The years passed by. Many designers struggled over the task of developing an underwater weapon. In 1807 LTC. I. I. Fitstum, an artillery and fortification instructor of naval cadets in Russia designed the first successful model of underwater mine. He carried out successful experiments involving the explosion of small mines laid on the bottom of a river. The mines were exploded from the shore with the aid of a special kind of Bickford fuze inside a hose.

Fitstum is also to be credited with the idea of exploding a mine charge by means of an electric current. This concept was brilliantly executed in 1812 by P. L. Shilling, a talented Russian scientist, who replaced the Bickford fuze with a thin copper wire by means of which the current was instantaneously transmitted from the shore and ignited the detonator of the mine.

So-called "Vlasov fuzes" played a great role in the development of ocean mines which operated independently and exploded on contact with a ship.

In 1826 Vlasov, a professor at the engineering academy proposed a very original mine fuze. It consisted of a glasstube with sulfuric acid which was placed in a cylinder, the lower part of which was filled with a mixture of Berthollet's salt and sugar. When the ship came in contact with the /8
mine the glass tube broke and the acid went into a chemical reaction with the salt. In the process the sugar burned in the acid and gave off a great amount of heat, causing the powder charge of the mine to explode.

The outstanding Russian physicist, B. S. Yakobi, proposed a mine floating under water which was held at a certain depth by a line. A weight was attached to the lower end of the cable (fig. 2). The electric fuze of the mine received its current by a wire from the shore, and the explosion occurred automatically the instant a vessel struck the shell of the mine. During the time a friendly ship passed over the mine it could be rendered safe by simply disconnecting the current to it.

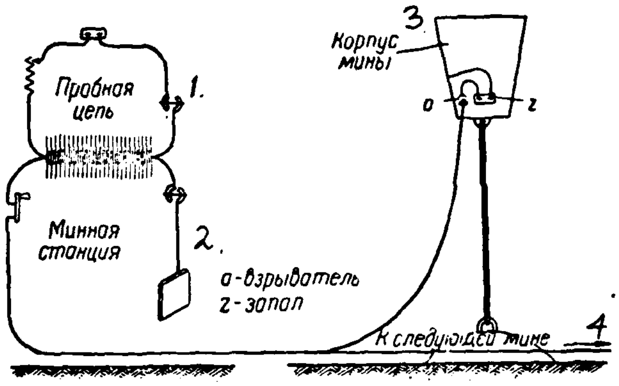

Fig. 2. Diagram of circuit for controlling the explosion of a mine; this idea was developed by B. S. Yakobi, a Russian professor.

Key: 1. Test circuit; 2. mine station; 3. mine shell; 4. line to next mine in series; a. firing mechanism; z. detonator.

A special group headed by Yakobi was set up to develop a new type of mine. This group included the talented Russian scientists P. L. Chebyshev, E. Kh. Lents, and some outstanding fleet officers.

The successful development of underwater mines in Russia yielded results. During the Crimean War the Russian Navy used the mine for the first time in history.

In the Russo-Japanese War (1904-1905) mines were employed in large numbers for the first time by the Russian fleet. More than half of all the Japanese vessels were sunk by mines in that war.

During the blockade of Port Arthur two of the newest of the Japanese ironclads , the Khatsuse and the Yasima, two cruisers, two gunboats, four destroyers, and two counter destroyers (destroyers with reinforced artillery and torpedoes) and a tender were blown up by the Russian mines and sank. In addition, an ironclad, two cruisers, a destroyer, and two counter destroyers were seriously damaged. 19

As a result of the successful employment of mines by the Russian navy men they rightfully earned the title of masters in the art of mine warfare.

The services rendered by Admiral Stepan Osipovich Makarov in the development of mines in the Russian fleet were great indeed. This outstanding naval leader and scientist foresaw the great potential of automatically functioning underwater weapons. He evaluated the role of the mine in the war at sea in the following words: "In my opinion mines will play a tremendous role in our future wars."

A variety of means for the employment of mines appeared in the Russian navy and were quickly developed. In 1892 the Russians were the first to build special ships to be used in planting mines. They were the Bug and the Dunay, surface mine layers.

In like manner the mine field was first developed and put into practice in our country. The plan of the mine field was proposed by a Russian technician, Mikhail Petrovich Naletov. During the Russo-Japanese War during the difficult days at besieged Port Arthur he began construction of midget submarines, utilizing his own resources, whose only armament were mines. Workers, sailors, and soldiers provided much needed support for Naletov in his efforts.

The submarine passed its sea trails, but when Port Arthur fell the mine field had to be destroyed to prevent its falling into Japanese hands.

After the Russo-Japanese War Naletov continued to work on his plan for a minelayer. In 1906 he proposed a new design for a large minelayer, the Krab, which was built on the ways at Nikolayev and performed creditably during World War I.

In the early stages of the war the Breslau, an enemy cruiser, was blown up by mines secretly planted in the Bosphorus against the German-Turkish fleet by the Krab.

During World War I the mines produced in the Russian fleet were considerably more advanced than those of other nations. This weapon was skillfully employed, and the fleet was able to inflict heavy blows against the well armed enemy vessels. /10

The widespread employment by the Russian navy of mines planted in the Baltic Sea hindered the German fleet from active operations there. The planting of mines along the enemy coastline forced him to suspend navigation at times and to restrict ships to their bases even to withdraw them from the Baltic area entirely.

Because of the danger of being blown up by mines planted by the Russian ships in the Black Sea, German submarines and cruisers discontinued all sorties in this area also.

From the very early days of the struggle for Soviet power the new Soviet fleet correctly evaluated the importance of mines. Vladimir Lenin perceived in the underwater weapon a mighty force to be used in the defense of the Soviet Union's coastlines.

On 9 August 1918 Lenin issued his order to the Baltic Fleet command to establish mine fields forthwith in order to defend Petrograd from attack by sea. To put this into effect the navy dispatched the following vessels of the Baltic Fleet to the Gulf of Finland: the destroyer Metkiy, the destroyer Legkiy, and the minelayer Narova. They continued to lay mines during the months of November and December 1918. Many enemy interventionists that tried to break through to Petrograd fell victim to the mines.

The British squadron, on which the imperialists had laid great hopes as a striking force in the assault on revolutionary Petrograd, failed to attain its assigned objective, and, having lost a score of ships in battles with the Red Baltic Fleet, was driven ignominiously from the Baltic.

On 15 March 1920 in a telegram to the Revolutionary Council of the Republic Lenin called for the preparation of all naval forces (mines, submarines, etc) for the battle with Wrangel. On 28 May 1920 under the direction of Lenin, the Council of Work and Defense considered the problem of increased production of mines, deemed to be a most powerful underwater weapon.

During the period of the Civil War some 7,000 mines were laid in the seas and 500 were planted in various rivers. This action was of tremendous importance in the defense of the young Soviet Republic. During WWII and the Great Patriotic War mines were the principal tactical weapons for waging the war at sea.

TACTICAL CHARACTERISTICS OF MODERN MINES

Of the several underwater weapons, the mine has always been a reliable tactical devicein the formation of a stable defense in both wars, as well as in blockading enemy bases, ports, and narrow passages. /11

It is interesting to note that the range of employment of underwater weapons is very great. This can readily be seen by opening a map of the world and comparing the areas occupied by water and land: approximately 71% of the earth's surface is covered by water.

Modern mines compared with the old models are considerably more powerful in destructive characteristics, and the automatic design features of the latest moored and floating mines all have a high order of operating reliability. Bottom mines can be laid in shallow water, moored mines can be employed at greater depths, and automatic floating mines can be used in any kind of waters, regardless of depth.

After being set mines do not have to be monitored; they function automatically. These properties of mines permit submarines, surface craft or planes to lay them beforehand, thereby avoiding close contact with the enemy.

A ship can proceed along its course directly toward a mine without any indication of the danger that lurks ahead. And regardless of the armament it carries the mine can destroy the ship unless it can avoid contact with it.

It is very difficult to detect a mine beforehand, especially bottom mines located on the bottom of the sea, and make preparations to repulse a "mine attack."

The mine suddenly explodes beneath the ship, therefore it is not always possible to take the necessary action to save the ship. Even in cases where the ship does not go down after coming in contact with a mine the damage is usually so serious that it loses combat efficiency and its capacity to escape and, therefore, it can be readily destroyed.

Particularly dangerous to aircraft carriers are holes in the hull because of the list in the vessel that results, thereby making takeoffs and landings impossible from the carrier's decks. Cariers bereft of their "wings" become impotent and good targets for enemy action.

Submarines which have been blasted by mines are usually lost. If the submarine survives the mine explosion and surfaces it can readily be detected and destroyed. The elements of concealment and surprise of an underwater /12 strike by a mine instill fear in the enemy of this massive type weapon of the sea. The constant watchfulness and the fear of encountering a mine along its course make it necessary for modern ships to carry a wide variety of complex devices essential for the detection of mines and protection against them. With the slightest suspicion of the presence of mines in a particular region a careful inspection is made of the sea lines and not until then may warships and merchant vessels out to sea.

On finding even a small number of mines an area is proclaimed to be a danger zone. The large scale employment of mines is explained by the fact that it is a comparatively simple, cheap weapon. From the time it was invented and in each successive war mines have been used on an ever-increasing scale. As far back as the Russo-Japanese War the two warring sides had planted a total of 6,365 mines; during World War I about 310,000 of them were laid; and in World War II about one million mines had been deployed.

Mines do not distinguish between enemy and friendly ships and explode underneath any ship which has crossed the boundary line of a mined area. In order that ships may not be destroyed by their own mines it is necessary to know the location of the mine fields and follow special channels -- narrow passages through mine fields. Information concerning these channels is a closely guarded secret and their location is changed periodically.

A mine can damage or destroy a ship only if the latter approaches it close enough or if the ship strikes against it. The fact that mines are "tied down" to the area where they are laid is oftentimes regarded as a shortcoming of this weapon. However, this feature of mines is extremely valuable in setting up stable and long lasting underwater barriers.

A mine cannot damage a ship from a greater distance, i.e. it has a limited range of action, and this is its principal shortcoming; to increase the probability of destroying a ship it is necessary to increase the number of mines in setting up a mine field.

The art of laying down a mine field consists in overlapping areas of the greatest importance to the enemy with the least expenditure of mines. /13 Increasing the effective range of modern mines is achieved by the placement in them of highly destructive charges along with automatic devices which are capable of exploding mines at certain fixed distances from the target. In such case the total expenditure of mines is sharply decreased and the quantity of men and means necessary for plating the mines is reduced.

MINES IN NAVAL WARFARE

During the past war the naval fleets of the warring nations resolved the most varied tactical missions which were carried out independently or in cooperation with the ground forces. The principal tactical operations of the defferent navies consisted in destroying the enemy's fleet elements, disrupting his industrial and military water supply routes, and in executing and supporting naval assault landings.

The tasks of naval fleets also included protecting the sea and coastal lines of communication against enemy attack from the sea and in fighting off seaborne landings. Mines have been of great importance in the war at sea. Mines were employed in so-called active, tactical, and defensive mine fields.

Active mine fields were laid down in enemy waters mainly under concealment. They destroyed enemy submarines and surface craft, created a continuous, prolonged threat to the free navigation of his vessels, pinned down enemy shipping, and restricted his tactical operations. Tactical mine fields were used in armed warfare with enemy naval forces for offensive and defensive purposes. They were laid in various areas of the ocean and were operative over a specific period of time, such as the duration of a naval action and withdrawal from it. On the expiration of such a period the mines exploded or sank.

The main purpose of defensive mine fields is to securely shut off the approaches of enemy submarines and landing craft from the sea into the defensive zone and, in addition, to prevent enemy ships from entering into areas from which they could strike coastal targets with naval artillery.

With the beginning of WWII all of the warring nations set up mine fields both along their own coastlines for defensive purposes and in enemy waters as well. Even certain of the neutral nations used mine fields to protect /14 their neutrality, taking into account the fact that mines are capable of providing a prolonged, reliable defense against the penetration by sea of undesirable guests without manifesting their tactical characteristics until the boundaries of their defended area are violated.

The conducting of mine warfare was begun with the mining of vast water areas. This was carried out basically with the aim of constraining and disorganizing sea lines of communication and impeding warship navigation and merchant shipping activities. Several minefields were laid down in order to prevent enemy submarines from penetrating into friendly sea lanes. For example, the band of minefields laid by the British along the English coast provided cover for the coastal shipping channels used by the British fleet.

Minefields planted by the Red Banner Baltic Fleet at the mouth of the Finnish Gulf and the Straits of Irbensk at the beginning of the Great Patriotic War constituted a powerful system of defenses. The large formations of enemy ships which attempted to breach these lines suffered huge losses. During the course of the war our fleet developed a mine and artillery position in the central portion of the Finnish Gulf which formed an insuperable barrier to enemy submarines and surface vessels and thereby protected Leningrad against attack from the sea. One distinguishing feature of mine laying during World War II is that many mines were planted with the object of striking the enemy in his own waters.

The advent of aviation-borne mines made it possible quickly to plant active minefields from the air. During the Great Patriotic War our submarines and air elements laid down many offensive minefields in the enemy's communication lines, blockading his warships and merchant vessels in their bases.

Aircraft were able to set the mines directly in the roadsteads, harbors, channels and in the rivers in the enemy rear. Mine dangers forced all /15
ships to be on the watch on all water communication routes. Merchant vessels that were supplying the army and navy were blown up by mines; ships were lost not only on the high seas and along the coastline but also in their own harbors and rivers which had formerly been considered inaccessible to mine laying by the opposition. Minefields were especially effective in the campaign against submarine. Submarines which had the valuable tactical capacity of hitting the enemy with secrecy and surprise now had to deal with a treacherous foe -- the mine.

The tactical effectiveness of mines is often judged by the number of ships destroyed by mines. However, this method of judging should not be considered wholly correct since the tactical problems of mines are not restricted merely to sinking ships; mines can make a large ocean area inaccessible to navigation.

According to information available the number of submarines and surface vessels destroyed by mines during the past wars is very impressive. During WWI over 200 warships (nine battleships, ten cruisers, 106 destroyers, 58 submarines, and 24 ships of other classes) were destroyed by mines, not counting special vessels, like minesweepersthat were blown up while sweeping areas for mines. Germany alone lost about 100 ships, the greatest losses being in the Baltic Sea due to mines planted by the Russian navy. 48 warships were lost here and over 20 vessels, in addition to transports and merchant ships, were seriously damaged due to exploding mines.

Great losses were suffered by the commercial fleet whose ships were less well protected against mines than warships and lacked sufficient capacity to stay afloat when damaged. About 600 ships of different countries were destroyed by mines and sank to the bottom.

The following are some of the ships that were blown up by mines and lost during WWII. In December 1914 the German battle cruiser Hoeben struck a mine in a minefield laid down by the Black Fleet in enemy waters and was put out of action for several months, and in April 1915 in the northern part of the Odessa minefield the Turkish cruiser Medzhidiye was blown up and sank to the bottom.

In March 1915 the French battleship Bouver was blown up by a mine in the Dardanelles; this detonation caused the ammunition magazine to explode and in minutes the ship went to the bottom.

In November 1914 the German armored cruiser Friedrich Karl was blown up by Russian mines and sank; in 1915 the Bremen, a former passenger liner, sank after coming in contact with a mine. During that same year the cruisers Asburg, Gazelle, and Danzig suffered mine damage.

In November 1916 seven of the newer German destroyers were lost in a forward mine position laid down by the Russian Baltic Fleet. /16

In the summer of 1918 the San Diego, a United States armored cruiser struck a mine laid down by a German submarine along the American coasline and sank in half an hour.

The examples cited by no means exhaust the many instances involving the sinking of large ships, but they demonstrate how powerful underwater attacks by mines can be to shipping.

During WWII mines, especially airborne mines, were very powerful military weapons which were successfully employed against enemy merchant vessels and warships. The mine became an active weapon in offensive operations on the seas and was used by all warring nations. During that war one enemy ship was blown up for every 50 mines laid down in the tactical minefields planted to oppose the German fleet.

Island nations like England and Japan were in especially difficult straits. Mines dropped by planes and submarines into the most important sea lanes tying these islands to the continent cut off the flow of strategic raw materials for use in industry and food for the populace. About two thousand minesweepers were assigned to the task of clearing mines from the more important channels along the coast of England, but even that force was inadequate to cope with the massive numbers of mines planted.

The British regarded the war against the mine menace as a vital factor insofar as the survival of the nation was concerned. They organized an extensive network of observation posts along the coast and at sea to determine where enemy mines had been laid. A special organization headed by the

Prime Minister of Britain was set up to invoke the populace for the campaign against the mine menace.

Mines were very effectively employed in rivers, channels, and narrow straits. For example, 2,500 aviation mines dropped in the Danube cut off the flow of petroleum by this important transportation line, and over 330 ships were damaged or sunk.

Even a small number of successfully planted mines oftentimes caused tremendous losses, especially in areas of intensive navigation. In 1941 German planes dropped acoustic mines in the Suez Canal which blew up and sank three ships, thereby closing off the canal. The canal was considered dangerous to navigation for a long time and it was necessary to trans-ship the cargo via rail, and that required much time. /17

During the war this canal, which was of great importance in the transportation of military cargo, was frequently mined by the enemy. For this reason it was closed for several months, thereby leading to tremendous losses in time and equipment.

At one time the British air force dropped 11 mines in the Kiel Canal. Although no ships were lost as a result, nevertheless traffic through the canal was interrupted for a long time. German industrial enterprises ran out of raw materials.

According to foreign press reports the military and merchant fleets of the different nations involved in World War II suffered huge losses because of mines. These included over 500 German warships and about 550 merchant vessels; 240 United States naval ships, over 280 British warships and about 340 merchant vessels; and 107 Japanese warships and over 350 merchant vessels.

During the course of WWII the mine menace in shallow ocean areas, lakes, and rivers oftentimes became the main danger. One indicator in this regard is the fact that at the end of the war the Germans were forced to build special ships to cope with the mines even though it was at the expense of reduced construction of submarines.

It is important to comment on the role played by mines in combatting seaborne landings.

The Normandy operation was a vast undertaking involving the seaborne invasion of the European coast. It was launched on 6 June 1944. Participating in it were several thousand warships, transports, and landing craft. A tremendous number of aircraft supported the land operations from the air. Much attention was directed to mine countermeasures. As a result of the collosal superiority of allied naval and air forces, as well as the weak German defenses it was possible with only a few large minesweepers at the beginning of the operation to clear channels to the coast in the Cherbourg, Cannes, and Havre areas. During that time ten flotillas of /18 minesweepers incessantly conducted reconnaissance sweeps in the maneuvering area of the ships which were supporting the landings.

However, despite their vast superiority in naval and air forces the joint U.S. and British command could not clear the mines in the landing area. German planes continued with their mine laying operations, and during the Normandy operation they dropped more than 500 mines which resulted in the loss of 43 ships by the joint U.S. - British command.

During the Korean War, which was launched by the aggressive circles in the United States, the attempt by the Americans to make a seaborne landing at the Korean port of Wonsan in October 1950 proved unsuccessful. The plan was to land 50,000 troops, unload a variety of military equipment in the Korean People's Republic rear, and launch and attack. This invading force consisted of seaborne equipment of many varieties and about 250 warships.

The Americans made preparations to repulse attacks by surface vessels, submarines, and aircraft, as well as to land troops on the hostile shore. However, their seaborne landing was not prepared adequately to cope with mines. Therefore, upon receiving intelligence reports that there were minefields facing the Port of Wonson, the commanders of the operation were compelled to halt the movement of this armada. Heavily armed ships, including battleships, aircraft carriers, cruisers, and others, proved to be helpless in the situation and the 50,000 man force was obliged to wait at sea while the mine menace in the path of the ships was cleared.

The Americans counted on a schedule of five days to clear the mines. A helicopter, which flew in front of the minesweepers, was used to spot the mines, which were subsequently destroyed. By the end of the first day only 21 mines had been spotted and destroyed.

On the following day the process of clearing the channel continued at a slower pace. It became clear that the five day period schedule for the destruction of the mines was unrealistic. To hasten the channel clearing operation it was decided to bomb it from the air. The Americans hoped to destroy any mines in the channel by exploding them with airborne bombs.

Thirty-nine bombers were assigned to the project, dropping 100 bombs at each pass. But the results were not very significant. Two minesweepers were blown up by mines in the channel which had been bombed from the air that very day. /19

Continued work on the destruction of mines continued with very great care at a still slower pace. The helicopter made its observations from the air, divers from launches sought out mines, and when they located one a floating marker consisting of an empty wooden crate and an anchor were attached to indicate the position. The minesweepers followed these reference markers and destroyed the mines. This was really an antiquated method of coping with mines, but the Americans could think of nothing better.

Clearing the channel was hopelessly delayed, therefore the landing force command informed the Commander of U.S. Naval Forces in Korean waters that it was impossible to carry out the landing operation in the Wonson area because of the serious danger presented by the mines. The landing operation was delayed for several more days. A communique was transmitted to the Pentagon which began: "The United States Navy lost dominance in the Korean waters."

The commander of the United States Navy made the following announcement: "They took us by surprise. These accursed mines cost us eight days delay in the seaborne assault landing and over 200 men killed. This in itself is a serious matter. But I can easily imagine a situation when an eight day holdup along the coastline could mean losing a war. If we are not in a position to go where and when we please then we don't have dominance at sea. And this is the basic element of all our military planning. We were seriously preoccupied with the threat of submarines and planes, and since a week ago we have been stymied by the mine menace."*

* G. F. Elliot. The New Russia -- A Threat to our Naval Might, Colliers, 4.9.1953.

Regardless of the measures taken by the Americans they still could not cross the minefield in the Wonson area.

It became necessary to land the invasion force in another area. The Americans themselves admit that the assault landing was made on a beach held by the United States Army, hence the assault landing was meaningless and was simply a deliverance from sea captivity in which they had been held for several days.

The naval mines set by the Korean People's army for the defense of their shores brought many unpleasant surprises to the armed interventionists and resulted in heavy losses to their ships.

The United States, Great Britain, and Japan promptly dispatched a /20
considerable number of special ships to Korea to sweep the area for mines. But the ships of the interventionists continued to be blown up by mines until the final days of the military operation.

UNDERWATER MINES, SURFACE VESSEL-BORNE AND AIRBORNE MINES

Vehicles carrying mines should deliver them to the proposed mine field area and properly lay them. One of the advantages of mines is that they can be planted by submarines, surface craft, planes, helicopters, dirigibles, and even ordinary barges and boats.

Selection of a carrier for laying mines, obviously, depends on the conditions, the site, and the objective of the minelaying operation. If it is required to set up a large area minefield quickly to provide defenses in friendly waters, for example, all types of carriers can be called upon to perform the task simultaneously.

In selecting carriers to plant mines in enemy waters special attention is given to the matter of delivering the mines surreptitiously to the proposed minefield area and avoiding attack by the enemy.

Submarines have been widely employed since World War I for laying minefields. Modern submarines are capable of maneuvering under concealment at high underwater speeds, travel great distances, launch surprise attacks upon the enemy and avoid attacks by the latter, and set mines in enemy waters unobserved.

Submarines can operate singly or in groups when laying mines or setting up minefields without need for special protection. Mines can be planted by submarines equipped with torpedo launching gear. In such case mines are taken on instead of torpedoes or are carried as supplemental armament and on the ocean bottom via the torpedo tubes. Some American submarines can carry up to 40 different kinds of mines.

However, the basic tasks involved in laying mines can be carried out by special submarine minelayers which are capable of taking on a large number of mines and have all the necessary devices for laying them quickly.

In laying down offensive mine fields submarines may run into considerable difficulties inasmuch as the approaches to vitally important installations /21 inasmuch as the approaches to vitally important installations are protected by fleet and air force antisubmarine elements, and in the coastal and shallow water areas antisubmarine nets and minefields are set up which are a source of great danger to submarines. Therefore, the methods for laying mines by submarines are under continuous development.

In 1959 a manual, "Principles of Naval Ordnance and Gunnery," was issued by the United States Navy for use of Naval personnel which state in part that the U.S. Submarines carried special mines which, on emerging from the submarine tube, are capable of floating underwater independently over a great distance for a certain period of time; these mines move forward to the area earmarked for the mine laying operation. It is apparent that such mines can be directed from submarines to areas of difficult accessibility, as well as to areas which had previously been mined. In addition, the United States and Great Britain have special, small-dimensioned submarines for penetrating into the more important areas and laying down mines, including mines with atomic charges.

The widespread use of air elements for planting mines did not begin until World War II, although the proposal to lay mines by this means had been made as far back as 1916 by Captain First Rank I. A. Kovalevskiy, a Russian naval officer.

Aircraft could effectively establish mobile mine fields until an effective means appeared for their long range detection and destruction. Under modern conditions the active concealed laying of mines by planes has been greatly complicated.

The chief advantage of aviation lies in the speed with which mines are delivered over great distances and the capacity of planes to penetrate into areas which are inaccessible to other types of mine carriers. Therefore, much attention is given in the imperialist armies and fleets to the matter of improving the methods of laying down aviation mines.

The U.S. Air Force has the important mission of laying down antisubmarine and anti-landing mine obstacles and minefields, especially during /22 the initial period of military activities. Mention is made in the foreign literature that mines can be planted by planes even in areas with strong air defenses. In this case the United States proposes using special glide mines which can be air dropped at a considerable distance away from the mine laying area.

According to the foreign press every bomber that joins the fleet has everything necessary for taking on mines and dropping them at high speeds. The United States has constructed a hydroplane, the Sea Master, which is designed to plant mines at supersonic speeds. It can carry up to 13 tons of cargo. Not only aircraft, but helicopters and dirigibles,which can carry a tremendous amount of mines, are adapted to mine laying; they are able to drop them more accurately than planes.

Minefields covering large areas at a considerable distance away from the coast were usually set by special surface minelayers and large transport ships converted to minelaying operations. These ships have a long self-sustaining period and good seakeeping qualities. As a result, they are capable of setting the mines comparatively quickly in fewest trips, a fact that reduced the requirement for military forces needed to provide cover. During World War II, for example, eight converted transports carrying 660 mines each were used by the British in laying the so-called northern minefield. In laying down the Orkney Island system of minefields five converted merchant ships with an average capacity of 250 mines each were used.

Present day surface minelayers specially designed for erecting defensive minefields are capable of high speeds. The British Apollo type surface minelayers, for example, are capable of developing a speed of 40 knots.

Foreign specialists are planning to use small-sized speedy ships for laying down defensive minefields in inland waters or in areas where navigation is restricted to narrow passages. The number of mines carried by these craft, to be sure, is less than that carried by the large minelayers and transports, but by virtue of their high speed they are capable of putting to sea more frequently and taking on and laying down mines more quickly. The loss of one of these small craft cannot be very perceptibly reflected on the rate of laying down the entire minefield.

According to foreign press reports* the Americans are building special minelayers for putting down remote controlled mines. Minefields made up of these weapons will be set out in advance and armed by means of underwater signals.

VARIETIES OF NAVAL MINES

Many different models of mines are organic weapons in foreign navies. This is explained by the fact that a variety of tactical missions have to be resolved with the aid of mines.

Depending on the methods used to hold mines in position they are subdivided intofloating mines, moored mines, and bottom mines (fig. 3).

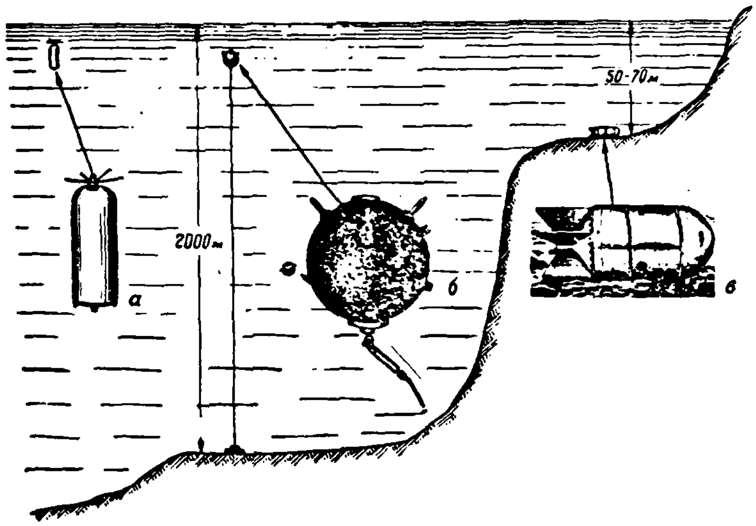

Fig. 3. Different types of mines based on their ability to maintain the set position:
a. Floating mine; b. moored mine; c. bottom mine.

After being set floating mines drift with the current, holding a given depth beneath the surface by means of special devices.

In the case of moored mines the hull, which has positive buoyancy, is held at a given depth beneath the water surface by a cable secured to a weight at the bottom of the sea. This weight is called the mine anchor, while the cable which connects the anchor with the mine hull is termed the mooring rope.

Moored mines may maintain their set position for a long time with great reliability, which is their chief advantage. The maximum depth of the site for setting moored mines is governed by the length of their mooring rope. The length of the mooring rope in certain foreign models of mines is two thousand meters.

Bottom mines are set on the bottom of the sea. They are difficult to locate and destroy. The fact that these mines have no anchor or mechanisms for setting them automatically at a given depth greatly simplifies their design and permits construction of more compact mines.

The greatest depth at which bottom mines are set depends on the radius of action of their firing mechanisms and the size of the powder charge. Ordinarily, this depth for the foreign types of mines does not exceed 50-70 meters. Bottom mines can be employed against submarines traveling submerged in deeper waters.

In addition to the indicated basic types of mines the Italian, German, and British naval forces also used special delayed action mines which were secured to the bottom of a ship by frogmen.

Depending on the operating principle, mine firing mechanisms are subdivided into the contact, influence, and controlled types of firing mechanisms. In order for contact mines to explode they have to make direct contact with the ship (From this point on the term ship is used to denote a submarine or a surface ship). Contact is established when the ship strikes against the mine or when it comes in contact with the special antenna devices disposed on the mine hull or mooring rope, etc.

Influence mines are detonated when the ship is at a certain distance away from them.The firing mechanisms of influence mines react to the ship's physical field.* They have the capacity to sense the approach of the ship at a considerable distance away and to detonate the mine the instant the ship enters the destructive area of the charge. /25

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* The physical field of a ship is the space in which it is possible to detect the physical forces generated by the presence or passage of a ship. This field is located under water and extends in all directions from the ship, accompanying it wherer it goes.

Controlled mines have firing mechanisms which can be switched on or off from the shore by wire or by some other means. After they are switched on these mines function like contact or influence mines, depending on the type of firing mechanism installed.

There are special mines for use in rivers and lakes. They are smaller in dimensions and simpler in design that sea type mines, but practically all ocean mines can be laid in rivers and lakes if required.

Present day naval mines are subdivided, depending on the type of basic carrier, into three major groups (fig. 4): ship, submarine, and airborne mines.

CONSTRUCTION OF MINES AND MINE SWEEP OBSTRUCTORS

Surface craft may set mines of all types, i.e. moored, bottom, and floating mines. In the past war up to 80% of the mines were laid by surface craft. The moored mine was the main type of naval shipborne mine used. Both contact and influence firing mechanisms are installed in modern moored mines. The main parts of such a mine are the shell and the anchor (fig. 5).

The mine shell consists of a watertight metallic sheath. The firing mechanism and explosive charge are contained in the lower part of the housing. In moored mines of foreign design the firing mechanism and explosive, which weighs between 200 and 300 kg, are contained in the lower part of the housing. The instruments which make up the mine firing mechanism are contained in the upper part.

The shell should have a high buoyancy reserve since this governs its capacity to hold firm at a given depth in a rough sea and strong currents.

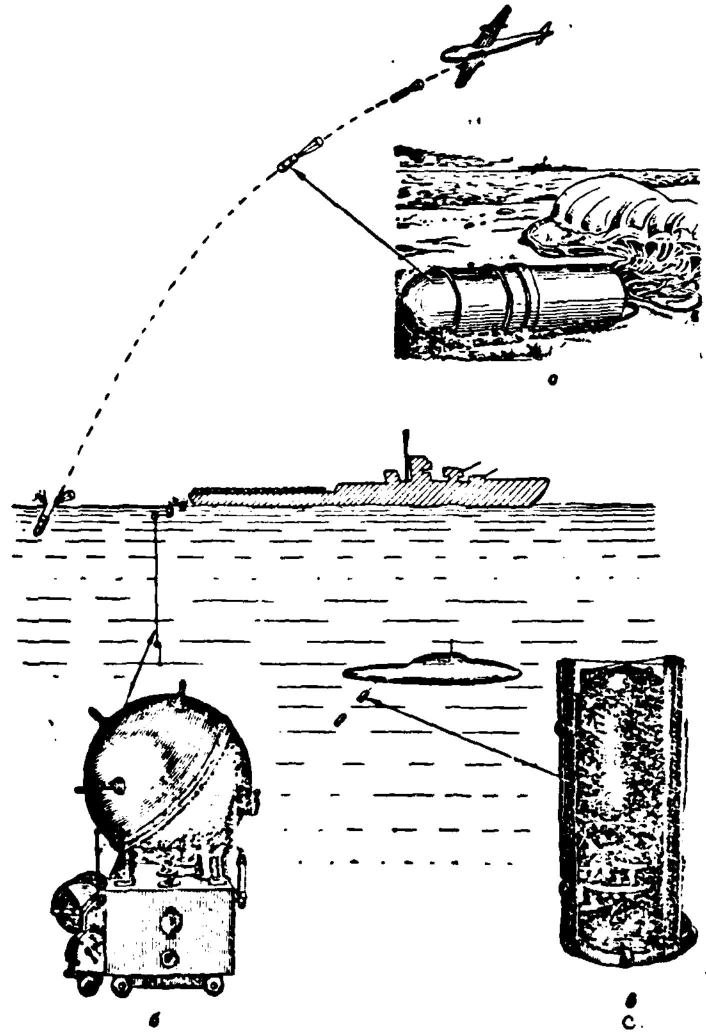

Fig. 4. Principal varieties of naval mines and their carriers:
a. Aircraft launched mine; b. ship-launched mine; c. submarine mine.

Construction of such a housing in the case of a ship-borne anchored mine is not a complex matter but the basic requirements should be observed: /27 the given dimensions and weight of the mine should not be exceeded in order that a greater number of them may be accomodated on a ship and that they may be readily handled on the deck and laid without difficulty when the ship is sailing at high speed.

The spherical shape of the mine housing should be preserved. This design permits the greatest hull capacity at least weight and provides maximum resistance to water pressure and the effects of explosions of nearby mines. In addition, ocean currents have less effect on a spherical shaped hull.

The mine anchor has a shape and weight such as to insure holding the mine in the set position. In addition, the anchor is made in the form of a dolly on which the mine housing is placed. The assembly can readily be moved about on the deck of a ship. A reel with flexible steel mooring rope and the mechanism for setting the mine at a given depth are contained on the anchor.

The most common method of setting a mine at a given depth is the plummet method of mine laying from the ocean surface. It was proposed as far back as 1882 by N. N. Azarov, a lieutenant of the Black Sea fleet. This method is simple and dependable and is still being used. It consists of the following.

The mine is dropped into the water (fig. 5) and first floats on the surface, the hull secured to the anchor whose air space has not yet been filled with water. Following that there is a separation of the weight which is connected by a thin line (lanyard) to the pantograph system mechanism designed to separate the anchor from the mine hull. As the line unwinds the weight suspended from it suddenly releases the reel and the mine anchor is simultaneously separated from the shell. The latter remains on the water surface while the anchor gradually settles to the bottom on becoming filled with water. As the anchor submerges the mooring rope is unwound from the reel under tension. As soon as the weight comes in contact with the bottom and slack develops on the line the stopper is immediately activated to check the reel. Reeling of the mooring rope ceases thereupon and the mine hull submerges due to the weight of the anchor to a depth equal to the length of the line. The length of the line with /29
weight is set beforehand in accordance with a preselected depth for the mine.

In the case of some moored mines the shell is set for a preselected depth automatically as it rises up from the bottom. This method of automatic mine laying was proposed by S. O. Makarov in 1882.

The mine planting process consists of the following. The mine is dropped into the water and immediately sinks to the bottom where it remains until the mechanism which separates the mine shell from the anchor is triggered (fig. 6a). When the housing separates from the anchor it begins to ascend and unwinds the mooring rope from the reel which is located on the lower portion of the shell. The stopper working off a hydrostatic /30
instrument secured to the mine housing stops the reel and the mooring rope

ceases to unwind. This occurs the instant the mine housing floats to a depth at which the external pressure of the water acting on the hydrostatic disk becomes less than than the stress of the spring holding this disk. Under these conditions the hydrostatic instrument will be activated and the stopper controlled by it will halt the rotation of the reel.

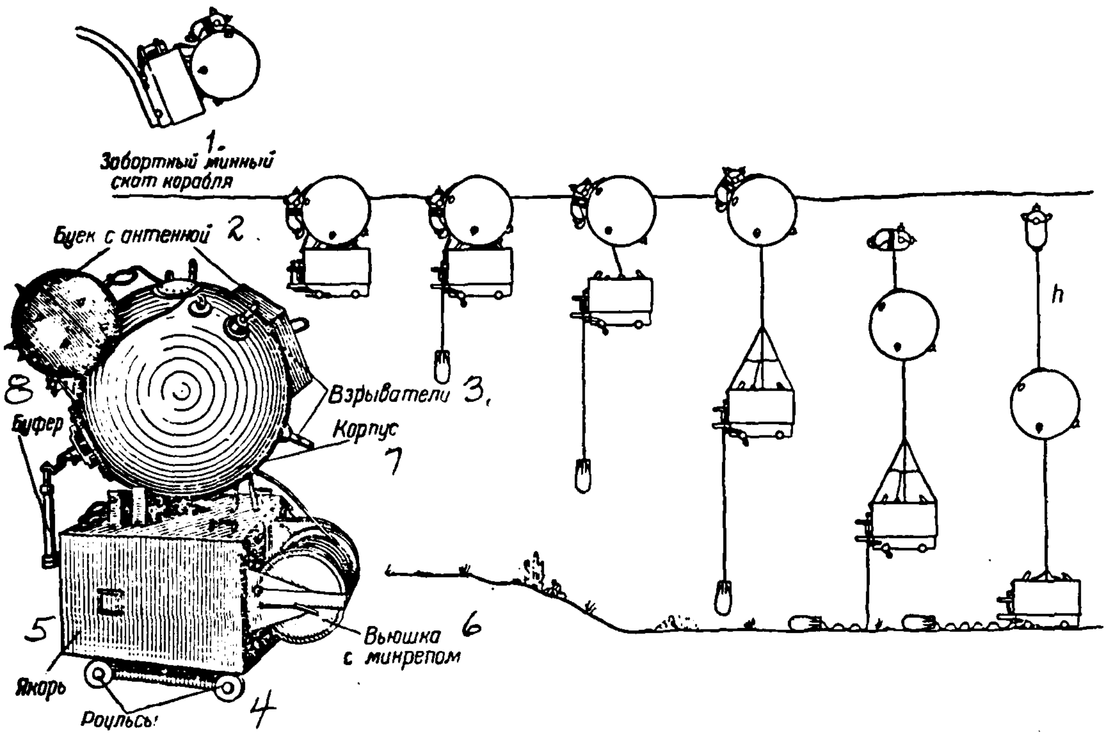

Fig. 5. Automatic setting of a moored antenna mine at a pre-selected depth from the ocean surface (plummet type method): h - depth of mine shell; 1. sponson rails for surface vessel launched mine; 2. buoy with antenna; 3. detonators; 4. rollers; 5. anchor; 6. reel with mooring rope; 7. shell or housing; 8. buffer.

The moment of activation of the stopper is set at the time the mine is prepared on the ship by changing the degree of spring compression in the hydrostatic instrument.

It should be noted that the reel with mooring rope contained on the mine housing reduces its buoyancy reserve. Therefore, some models of mines use the so-called "loop" method. In this system (fig. 6b) a portion of the mooring rope directly underneath the mine hull is gathered together into a loop that is held by the clamps of the hydrostatic device. The spring of the hydrostatic instrument is set, as in the above described method, according to the pre-selected depth of the mine. In this case one also takes into account the difference in depth by which the mine hull will rise when the loop is unwound. The reel with mooring rope is on the mine anchor, and when the hull floats upward the mooring rope is unwound from the reel which is under tension. The tension of the mooring line does not permit the stopper to halt the rotation of the reel when the shell ascends.

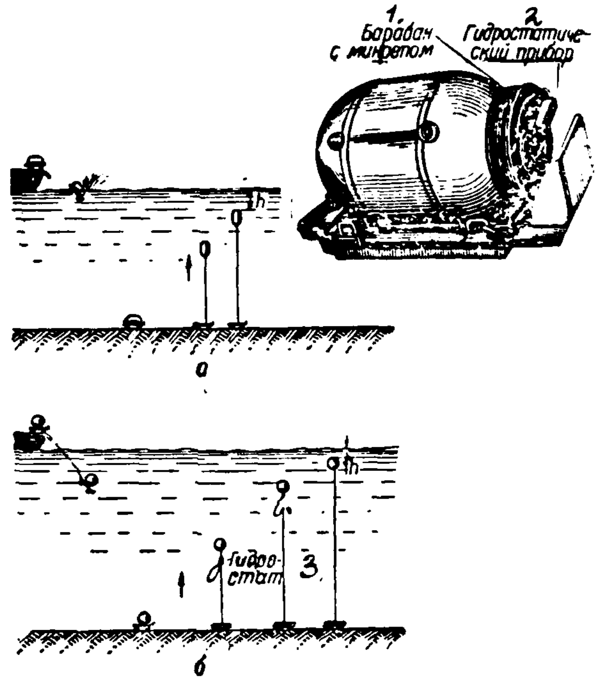

Fig. 6. Automatic setting of a moored mine as the shell floats upward from the bottom.
a. Setting a mine by ascending from the bottom by means of the "loop-free method"; b. setting a mine by the "loop" method; 1. drum with mooring rope; 2. hydrostatic instrument; 3. hydrostat.

When the mine shell reaches the depth at which the external pressure of the water on the disk of the hydrostatic device which holds the loop becomes less than the force of the spring the clamps of the hydrostatic instrument liberate the loop. The moment the loop is unwound the tension of the mooring line weakens and the stopper in the mine anchor is triggered, thereby stopping the rotation of the reel. The unwinding of the mooring rope ceases in the process which means that the mine shell has stopped at the pre-selected depth.

One advantage of all the methods of setting mines from the bottom is that the mines may have a hydrostatic arming delay surfacing switch and their hulls and anchors may remain on the bottom over a period of time established beforehand on the instrument. During this time it is difficult to locate and destroy the mine. The time of useful service of the contact anchor mine is limited, basically, to the useful service life of the mooring rope.

With time the mooring rope corrodes in water, loses its strength and, /31
when the seas are rough, may break loose. The waves oscillate the shells rather considerably when they are near the surface and the jerking effect on the mooring rope amounts to hundreds of kilograms of force; in the case of large dimensioned mines it amounts to several tons of stress.

Various kinds of shock absorbing buffers are used between the shell and mooring rope to protect the latter against wave action.

Controlled or so-called "engineer" mines were used during the war in addition to the automatically operated moored, bottom, and floating mines. These were usually laid from surface craft on approaches to ports, in narrow passages, and in channels between islands and on rivers. These mines (moored or bottom mines) were connected to the coast by electric cables (fig. 7). In the manual "Principles of Naval Ordnance and Gunnery" it states that an operator at a coastal post has the capability of exploding one or several mines with the appearance of an enemy ship in the minefield area. The signal of the appearance of an enemy submarine can be transmitted by the mine via cable to the distribution panel where bulbs representing individual mines light up when a submarine passes close by.

The controlled mine can be disconnected during the time of passage of friendly vessels through the mined area and it can be switch on at any moment; it can also be destroyed in order to clear an area of mines by exploding it on a signal from shore.

The chief advantage of "engineer" mines vis-a-vis autonomous (independent) action mines is the fact that their explosions are controllable.

Submarines lay mines of all types, including moored, bottom, and floating mines. Both contact and influence type firing mechanisms can be used in these mines. Moored mines planted by submarines operate like the shipborne anchor mines prevsiously described, but from the structural standpoint they are substantially different from them.

In the first place, the dimensions and weight of submarine mines are determined by the conditions of storage of mines inside the boat, as well as the system of planting them by means of the torpedo tubes or through the mine tubes of special submarine mine layers.

Secondly, the construction of a mine should always insure secrecy when it is planted. The American submarine launched anchor type influence mine (fig. 8) is adapted for planting from torpedo tubes. The shell is equipped with a special stabilizer which imparts stability to the motion of the mine along its trajectory as it submerges after leaving the torpedo tube.

The mines are automatically set at the assigned depth on ascending from the bottom.

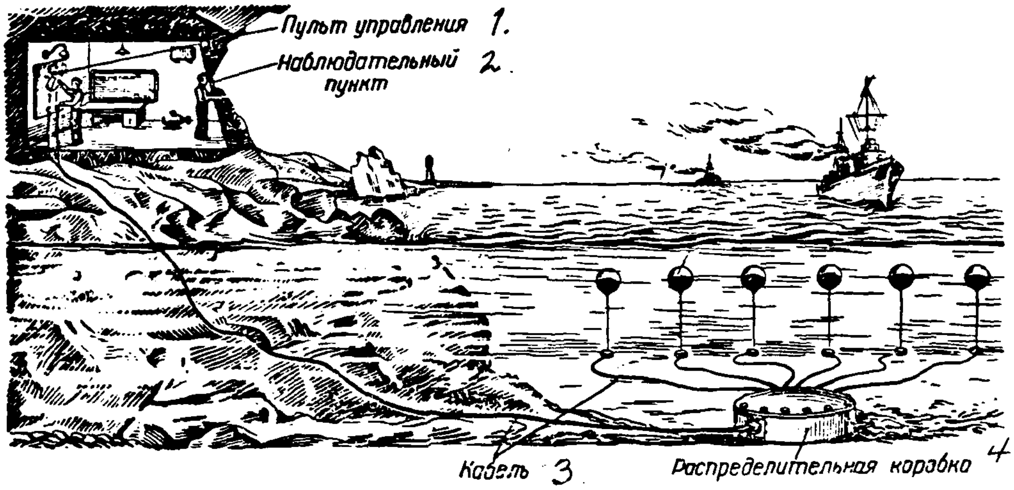

Fig. 7. Diagram showing the application of controlled mines. /32

1. Control panel; 2. observation post; 3. cable; 4. distribution box.

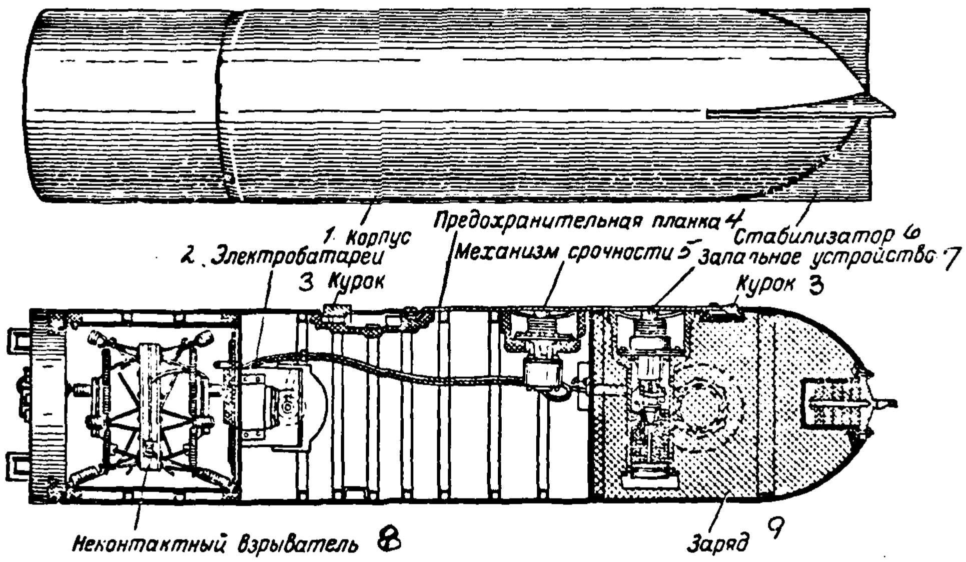

Fig. 8. American made submarine-borne anchor type influence mine, the Mk-10, model 3, designed for laying from torpedo tubes.

1. Casing; 2. electric battery; 3. starting lever; 4. safety cleat; 5. time mechanism; 6. stabilizer; 7. firing mechanism; 8. influence firing mechanism; 9. charge. /38

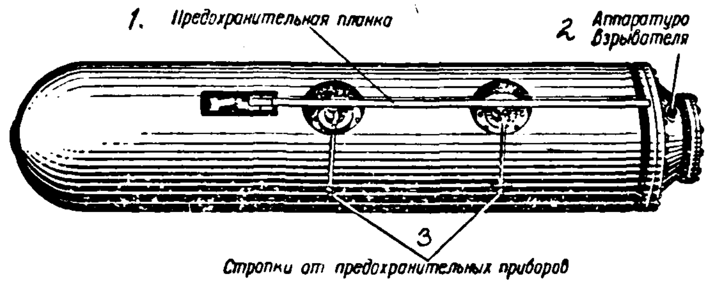

Fig. 9. American submarine-borne bottom type influence mine, Mk-12, model 0.
1. Safety cleat; 2. firing mechanism; 3. strops from safety device.

The mine casing is cylindrical in shape with a diameter corresponding to the diameter of the torpedo tube. The firing position of the casing is horizontal i.e. parallel to the surface of the water. This position reduces the effect of current on the mine casing and prvents it going too deep.

Fig. 9. snows an American submarine-borne bottom mine which is capable of being planted through torpedo tubes. Also of interest among the submarine mines are the floating types which automatically hold their floating depth. These mines are designed for use in tactical minefields which can be laid down by submarines. Floating mines are also laid by planes, but is much more difficult to maintain secrecy of operation in the process.

The first design for a floating mine kept automatically at a pre-set depth was developed in Russian in 1909 by Captain First Rank Ye. V. Kolbas'yev. Tests of this floating mine were carried out at sea and gave good results. The pneumatic principle of the mine floating apparatus is quite original. The author referred to it as the "fish bladder" principle. /35

With increased depth the mine automatically increased its buoyancy, and when rising it decreased the buoyancy; this process kept it at an assigned depth, i.e. it was set on the floating device the moment the mine was released into the water.

In 1913 S. A. Kalchev, a naval lieutenant, proposed a design for an automatic floating mine with an electrically operated floating system.

The operation of the motor is controlled by the hydrostatic instrument which works off the external water pressure and periodically switches in the storage battery to the electric motor. The American automatically floating mine has a floating instrument based on the use of an electric motor which turns a propeller located in the lower portion of the mine.

If the mine descends to a depth greater than that which is set on the floating device the hydrostat cuts in the electric motor. The motor turns the propeller causing the mine to ascend. As soon as the mine rises to the pre-selected depth the hydrostat disconnects the power to the motor. If the mine continues to surface the hydrostat will again switch in the motor. However, in this case the propeller will turn in the opposite direction and will cause the mine to descend. The accuracy of holding the mine at a given depth is within one meter. /36

Defense against automatically floating mines (fig. 10) is extremely difficult because the ordinary mine sweeps and ship paravanes do not recover these mines. As a rule, floating mines are equipped with destructive devices which either sink or explode the mine after a certain period of time.

Modern aircraft are capable of laying out mine fields using anchor, bottom, or floating mines. Contact and influence firing mechanisms can be installed in these mines. Most characteristic of the aviation mine is the bottom type influence mine.

The bottom mine is most simple in design and for that reason it maintains operational efficiency after being dropped into the water from a considerable height and at a high launching speed.

The first bottom type influence mine was proposed in our country by I. A. Averin, a student. However, it did not get widespread application or use until World War I.

Taking into account the present day level of development of the means for locating and destroying mines, military specialists abroad feel that bottom type influence mines should have high sweeping stability. To locate such mines requires searching virtually every meter of bottom, and destroying them requires exploding by means of special sweeps capable of reproducing the appropriate physical fields of a ship. However, this latter may not bring about the desired results because the builders of influence /37 mine firing systems took the trouble to provide them with clever devices which can differentiate between an artificially crdated sweep field and the natural field created by the ship.

In size and weight aircraft launched mines are similar to air-launched bombs, hence they are placed in aircraft that are adapted for bombing. Any bomber type aircraft can be used to carry mines. The U.S. bottom mine shown in fig. 9 can be dropped from any plane. Special shrouds are provided to switch in the instruments the instant the mine is dropped from the plane.

Mines may be dropped from a plane into the water with or without parachute, just like bombs. Fig. 11 shows the external view of a U.S. airborne anchor mine, which is dropped from a plane by parachute. The basic parts include the shell containing the charge and instruments; the anchor with /38 mooring cable; and parachute jacket with chute. The orifices in the mine shell contain instrumentation. Leading away from the instruments are strops by means of which the instruments are cut in the instant the mine is released.

The mines are suspended beneath the plane by means of lugs contained on bands which surround the shell.

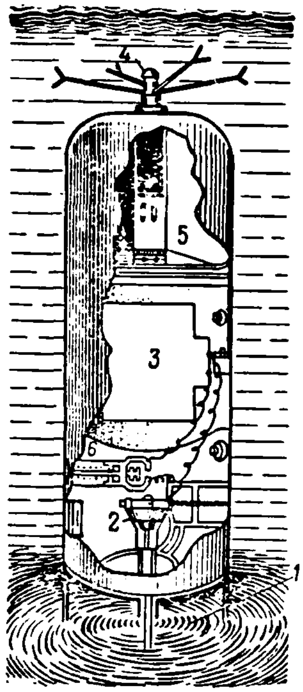

Fig. 10. Foreign made automatically floating type mine, the Leona:
1. Propeller of floating device;
2. electric motor; 3. storage battery; 4. firing mechanism; 5. explosive charge; 6. hydrostat for controlling the operation of the electric motor.

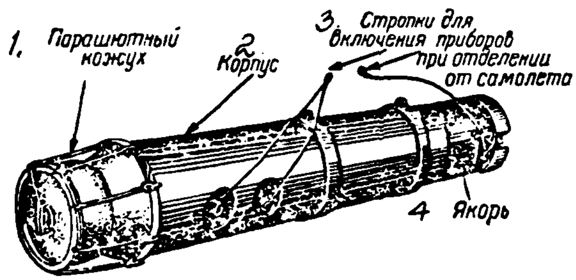

Fig. 11. U.S. Mk-10, Model 9 aircraft launched moored mine with parachute.
1. Parachute jacket; 2. shell; 3. strops for cutting in instrumentation when mine is released from aircraft; 4. anchor.

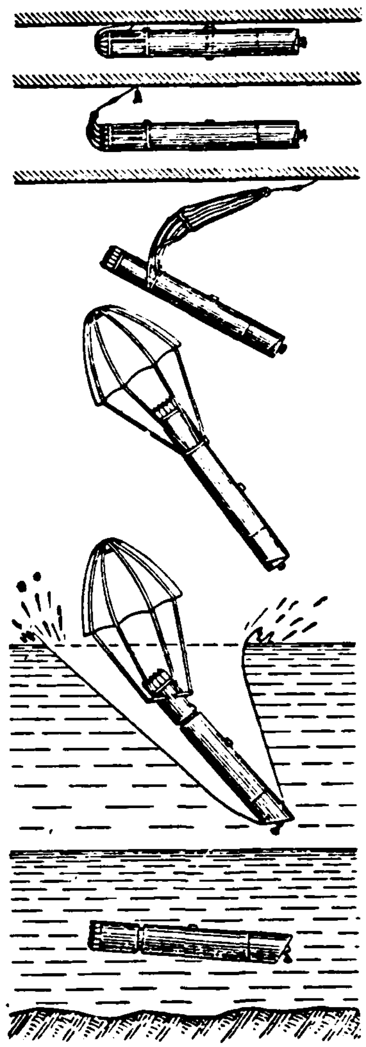

Fig. 12. Operation of a parachute system.

When the mine is released from the plane (fig. 12) the strop which is connected with the parachute jacket valve tips is extracted from the valve openings, causing the valves to open up; the halyard then extracts the parachute out of the jacket.

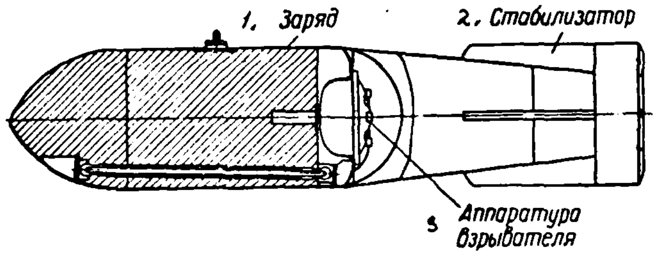

Fig. 13. German made type BMA-II aircraft launched mine without parachute.
1. Charge; 2. stabilizer; 3. detonator system.

As the mine drops the parachute is filled with air and reduces the speed of entry into the water. When the mine enters the water the parachute locking device releases the parachute from the shell.

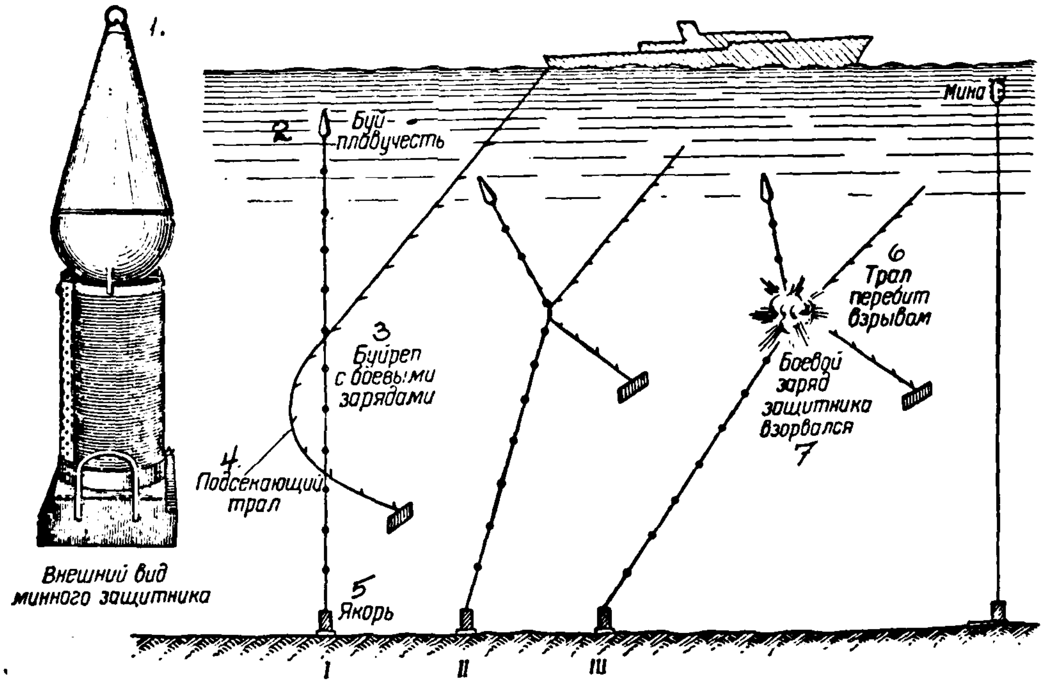

Fig. 14. Sweep obstructor and diagram illustrating its action against moored mine destruction sweeps. 1. External aspect of sweep obstructor; 2. buoy buoyancy; 3. buoy rope with explosive charge; 4. cutting sweep; 5. anchor; 6. sweep destroyed by explosion; 7. explosive charge of sweep obstructor detonated; 8. mine.

Mines without parachutes at first glance appear to be simpler than those with parachutes, but this is not entirely so. A parachuteless mine dropped from an aircraft develops a high velocity of fall and thereby subjects the instrumentation to considerable shock on contact with the water. In order that a mine remain operationally efficient following such entry into the water it should have an extremely strong shell and especially rugged shock-proof instruments provided with good shock absorbing devices (fig. 13.).

The question arises why one should have parachute-less mines if they are harder to produce than mines with parachutes? The fact of the matter is that parachuteless mines can be laid with a high degree of accuracy. The same sights that are used for dropping bombs can be used for aimed dropping of parachute-less mines. In addtion, mines dropping at a high velocity without a parachute are considerably more difficult to locate after they are laid than those dropped by parachute.

Mine sweep obstructors (fig. 14) designed as a defense against sweeping
a field of moored mines constitute a special type of mine. The sweep /40
obstructors are set together with the mines. Their purpose is to cut through the trawling portions of the contact sweeps.

Sweep obstructors are simple in design and in most cases remind one of mines except that the explosive charges in them are contained not in the shell, as is the case with mines, but on the buoy rope, the line which connects the sweep obstructor to the anchor. In this case the buoy holds the buoy rope with explosive charges.

The explosive charge or firing unit, as it is referred to mine specialists, is provided with an igniter which detonates the charge automatically when it is depressed by the line portion of the contact sweep and breaks it up. The more modern sweep obstructors are designed to insure repeated action against sweeps.

DESTRUCTIVE FORCE OF AN UNDERWATER EXPLOSION

An underwater explosion has greater destructive force than one on the ground or in the air. This is explained by the fact that water is a high density medium. The shock wave formed in an explosion spreads at a tremendous velocity over great distances and carries with it approximately half of the total energy of the explosion.

In the case of an underwater explosion the shock wave, the hydraulic shock of the water mass, and the hot gaseous products of the explosion (depending on the distance) exert an action upon the ship.

If the center of the explosion is near the ship's hull, which is the case when a ship encounters a contact mine, the shock is exerted directly upon the external plating of the ship and ruptures it (fig. 15). The flow of expanding gases bursts into the interior of the ship at great velocity.

Small ships may sink as a result of such explosions while larger sized vessels sustain holes in the hull allowing large quatities of water to flow in.

The explosion of an influence mine charge usually occurs beneath the bottom of a ship. Such an explosion is most dangerous because the shock wave produces both local damage to the ship's bottom, thereby weakening /41 the entire hull, and causes it to bend generally in consequence of the non-uniform intensity of its action along the length of the ship. The size of the hole in this situation is sometimes greater than when the mine explodes near the side. Since it is practically impossible to provide a defense against mines on the bottom of the ship similar to the defenses for a ship's sides (this is associated with lessened metacentric stability and the ship's seaworthiness), the explosion of an influence mine beneath the bottom of the ship constitutes the greatest possible danger. There were instances during the war wherein the bow or stern portions of a large vessel were completely blown off by a mine and the vessel remained afloat, but when a mine exploded underneath the central part of the ship it broke into two parts.

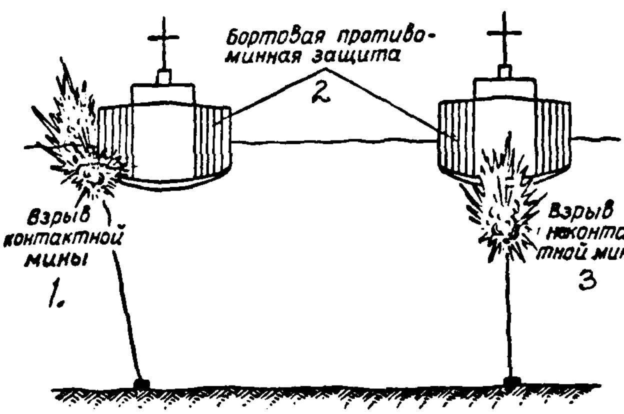

Fig. 15. Explosion on the side and beneath the ship's bottom.

Key: 1. Contact mine explosion; 2. antimine protection on the sides; 3. explosion of influence mine.

At the present time foreign models of influence type anchor mines activated at distances up to 2 -30 meters underneath the ship carry a 200 to 300 kg charge, while bottom mines which are activated at distances of the order of 30-50 meters from the ship carry an explosive charge of 750-1000 kg of TNT equivalent.* TNT type high explosives are used in mine charges (fig. 16). In an explosion these substances are very quickly converted

* U. S. Naval Institute Proceedings, No. 11, 1959.

into gases, releasing tremendous quantities of heat, and instantly produce

produce great pressures capable of pulverizing obstacles which obstruct the expansion of gases.

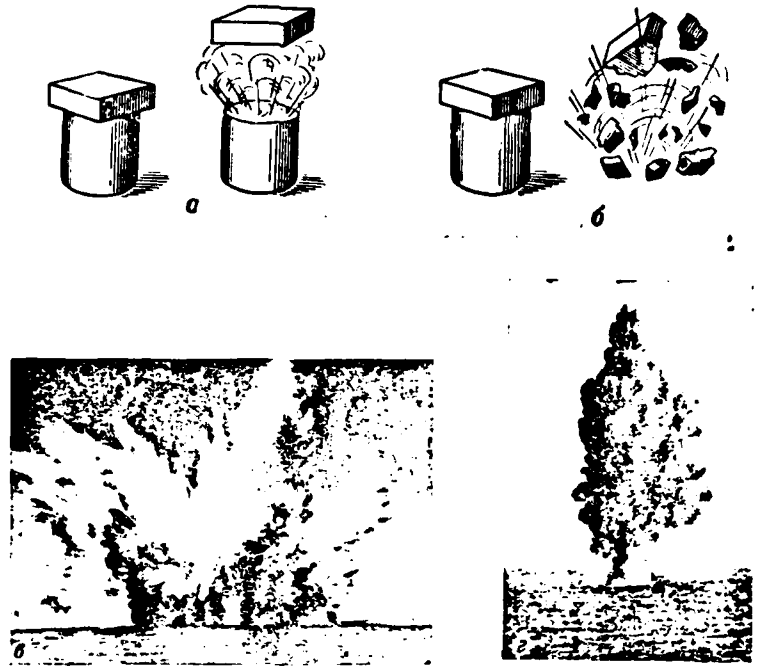

Fig. 16. Explosion and detonation: a. Explosion of powder charge; b. detonation of TNT; c. underwater explosion of a mine with a charge of TNT; d. underwater explosion of torpedo with TNT charge.

Explosives which have low sensitivity to shock and heating are selected for use as charges of mines and torpedoes, otherwise handling them on a ship would be very dangerous.

Ordinarily used as charges in present day mines and torpedoes of the United States and Britain are TNT, HBX and Torpex; all have a TNT base.

We learn from the foreign press that the U.S. and British navies have mines with atomic warheads with a charge equivalent of 20 thousand tons of TNT. The effective radius of such mines is tens of times greater than that of mines with TNT type explosive charges. /43

The underwater explsoion of an atomic charge with a TNT equivalent of 20 thousand tons is capable of inflicting serious damage, sinking, or putting out of action large warships, such as battleships, cruisers, and aircraft carriers at a distance of up to 700 meters, while at a distance of up to 1400 meters it is capable of inflicting damage greatly reducing the combat effectiveness of these ships.

In an underwater explosion of a hydrogen charge equivalent to one million tons of TNT the same kind of damage results to ships at distances five to ten times greater than in the case of an underwater atomic charge.

Radioactive substances can act with great intensity on the personnel of a ship in addition to the shock wave when an atomic or hydrogen charge is exploded underneath a ship. As a result of the explosion a tremendous mass of contaminated water rises above the ocean surface which rains down on the ship for several minutes in the form of a radioactive cloudburst. Ships at a distance of three kilometers and over from the point of burst of an underwater explosion may be greatly contaminated by radioactive substances. The contaminated radioactive fog is capable of spreading from the central point of the explosion over a considerable distance.

MINE FIRING MECHANISMS AND THE PHYSICAL FIELDS OF SHIPS

Electric and percussion firing mechanisms (fig. 17) are used, for the most part, in contact type anchored and floating mines. The galvanic cell they carry is contained in metallic (usually lead) caps located on the mine shell surface. Lead caps are covered over with cast iron protective caps which are automatically ejected by springs after the mines are planted. The galvanic cell consists of a carbon (positive) and zinc (negative) electrodes and an electrolyte. The electrolyte is placed in a glass container positioned above the electrodes.

When the ship comes in contact with the mine one or several of the caps collapse. The glass container inside the cap breaks, the electrolyte purs over the electrodes, and the cell becomes an electrochemical source of current instantly. The current from the electrodes connected by conductors with the electric detonator of the mine passes through the electric /45 detonator bridge filament, heats it to incandescence and ignites the primer which detonates the mine charge.

Inertia firing mechanisms are ordinarily used in moored mines. An inertia firing mechanism (fig. 18) is used as the detonating device in them.

When the ship strikes the hull of a mine the inertia weight which holds the firing lever by its head is shifted in position. When the head slides out from underneath the lever it drops down quickly with the firing pin due to the spring action. The point of the firing pin pricks the detonator of the primer and the charge explodes.

Inertia electrical firing mechanisms are used in moored and floating mines. Several rods extend out of the mine shell which are bent on contact with a ship or are pushed inward, connecting the mine detonator with the electric battery. /46

Electrical contact or so-called antenna firing mechanisms are used in mines which are employed mainly against submarines (fig. 19). The operating principle of these igniters is based on the characteristic of certain metals, such as zinc and steel in seawater to produce a difference in potential.

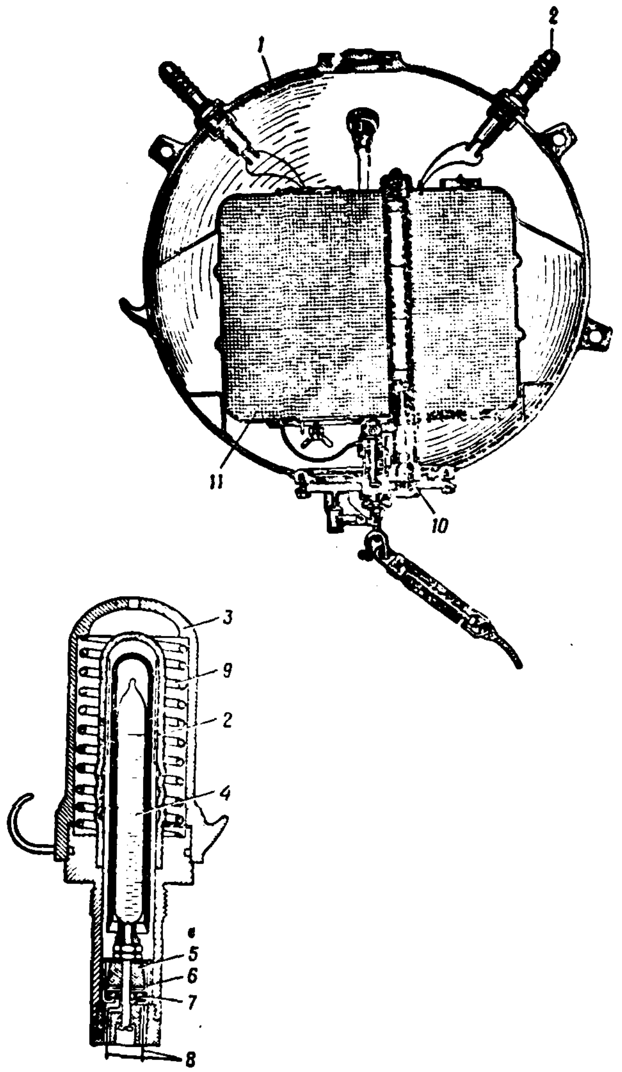

Fig. 17. German electrochemical mine. Key: 1. Mine shell; 2. lead cap with galvanic cell; 3. cast iron safety cap; 4. glass container with electrolyte; 5. carbon electrode; 6. zinc electrode; 7. insulating washer; 8. wires from carbon and zinc electrodes; 9. spring for ejecting safety cap after mine is laid; 10. electric primer; 11. mine charge.

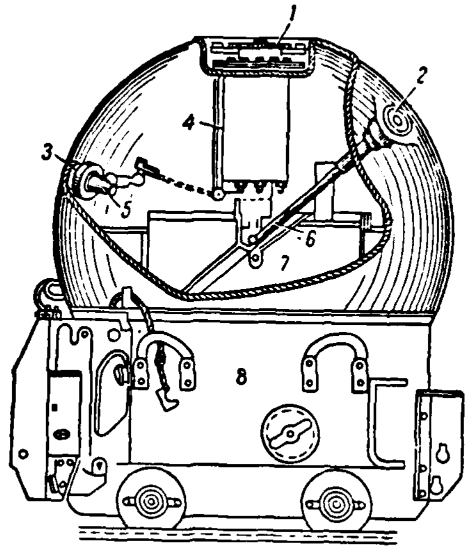

Fig. 18. Mechanically fired contact mine. 1. Orifice for inertia firing mechanism; 2. orifice for primer; 3. orifice for sinking valve; 4. inertia firing device; 5. sinking device; 6. primer; 7. charge chamber; 8. anchor.

Metallic antennas about 30 meters long each are secured above and below the shell of the mine to the antenna firing mechanism. The tips of the antennas turned toward the mine are connected together by a wire which passes into the mine shell. Therefore, the electrically connected upper and lower antennas represent an electrode. If the hull of a submarine comes in contact with one of the mine antennas a current will flow through the wire connecting this antenna with the second antenna.

The current obtained from such an electric cell is usually insufficient to heat the electric igniter of the mine to incandescence, therefore its energy is used as a signal for very sensitive instruments. After receiving a signal these devices connect the electric detonator to the source of direct current contained in the mine. A current of required magnitude passes through the filament of the electric detonator bridge, heats it to incandescence, and causes the mine charge to detonate.

It was demonstrated during the first World War that contact mine firing devices do not fully satisfy the requirements of mines because of the rather low probability of a ship encountering a contact mine. Therefore, the idea occurred of making firing mechanisms for mines which might be able to sense the approach of a ship from a considerable distance and to detonate the mine the instant the ship is in a position of dangerous proximity to such a mine.

The task was not an easy one but mine specialists succeeded in designing "eyes" and "ears", as well as an "automatic brain" which proved capable not only of sensing the approach of the ship but of exploding the mine independently and at the right time. This became possible only after the physical fields of a ship had been discovered and analyzed.

It is well known at the present time that a ship has a number of physical fields, including magnetic, acoustic, hydrodynamic, and other fields.

The physical field acting as if it were assisting the underwater weapon "increases the draft and beam of the underwater portion of a ship's hull many fold.

Devices for exploding mines which are activated by the influence of a ship's physical fields are known as influence firing mechanisms. The principle on which they operate consists in the following. On approaching the mine the ship acts through its physical field or fields upon the receiver of the triggering device of the mine which transmits a signal to the intermediate instruments and actuating mechanisms.

When the ship enters the area of the mine's destructive action the actuating device cuts in the electric current to the detonator which explodes the mine.

Advent of the influence firing mechanism insured the production of a new type of bottom mine and permitted the use of moored mines in seas with great tidal tidal action, as well as in areas with strong currents.

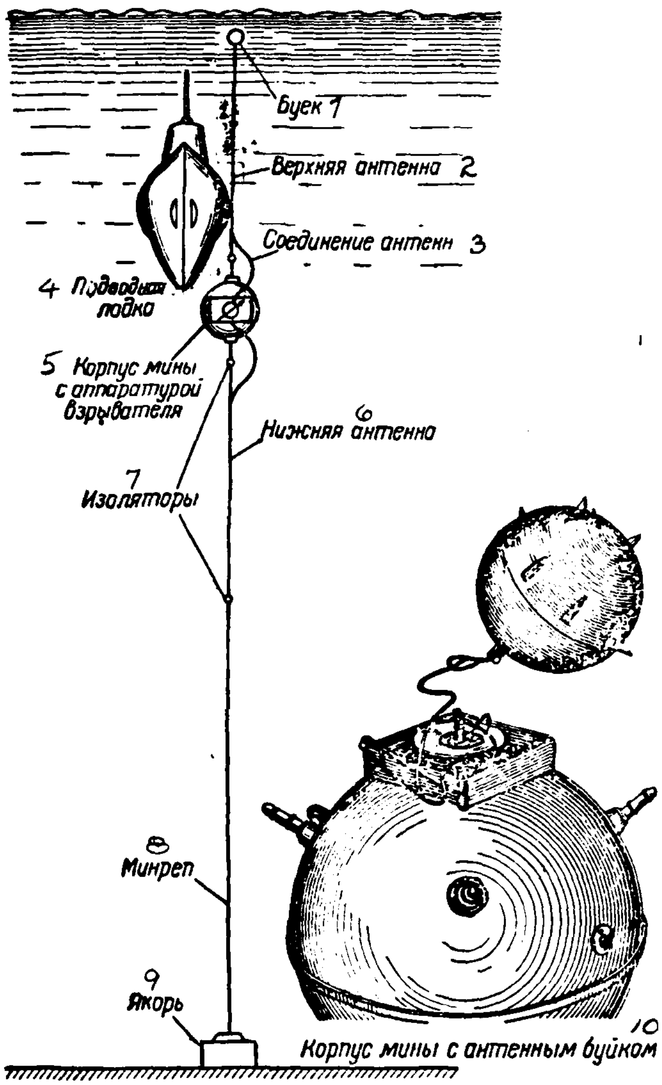

Fig. 19. The U.S. Mk-6 type antenna mine.

1. Anchor buoy; 2. upper antenna; 3. antenna connection; 4. submarine; 5. mine shell with firing mechanism; 6. lower antenna; 7. insulators; 8. mooring line; 9. anchor; 10. mine shell with antenna marking buoy.

Use of moored mines with contact firing mechanism in these cases is not very effective because during the incoming tide the water level rises several meters higher than the shell of the mine and the ship can pass over it seremely. During the outgoing tide the mines float to the surface and become visible to the enemy. In addition, in areas with high velocity currents moored contact mines cannot maintain the depth necessary to insure contact with a ship.

Influence moored mines can be laid at a depth (distance from the water surface) such that their shells may not surface during the outgoing tide, but during the incoming tides the mines are dangerous to vessels passing above them. The effect of strong currents and tides simply tends to lower the mine shell but its firing mechanism will nevertheless perceive the approach of a vessel and will detonate the mine at the necessary moment.

A ship with a metallic hull and a multiplicity of mechanisms made of ferromagnetic materials has the properties of a magnet.

The magnetic properties in a ship are due to the presence of the earth's magnetic field. As we all know, our planet is a tremendously large magnetized sphere with two poles. The magnetic pole is located not far from the geographic pole as can be seen in fig. 20. /49

The process of magnetizing a ship in the magnetic field of the earth begins the moment the keel is laid and continues until the construction of the ship is completed.

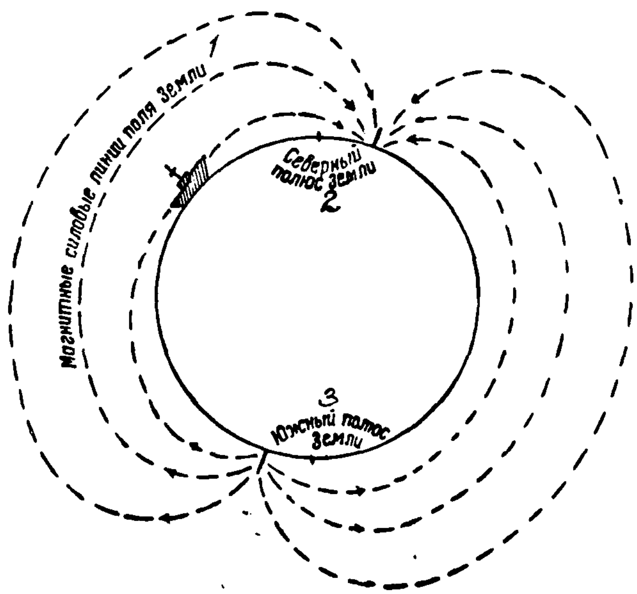

Fig. 20. The earth's magnetic field.

Key: 1. Earth's magnetic lines of force; 2. north geographic pole; 3. south magnetic pole.

When the completed ship begins to move it is also subjected to the effects of the earth's magnetic field which differs in magnitude with changes in the latitude where the ship is sailing and the ship's course. In addition, areas of magnetic anomalies are oftentimes encountered --

areas with an intensified magnetic field. Therefore, the ship's magnetic field while navigating can change substantially. /50

Let us consider the magnitudes of the ship's magnetic field. This magnetic field is generally described by a strength measured in oersteds.*

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* An oersted is the intensity of a magnetic field which acts on a unit of magnetic mass with a strength of one dyne.

The voltages at the different points of the magnetic field of a ship differ. Influence firing mechanisms of mines are capable of reacting to individual components of the magnetic field. One can get some idea of these components by a consideration of the following example.

The position of any point in the magnetic field with respect to the ship's hull can be described by its distance from three mutually perpendicular lines (coordinate axes).

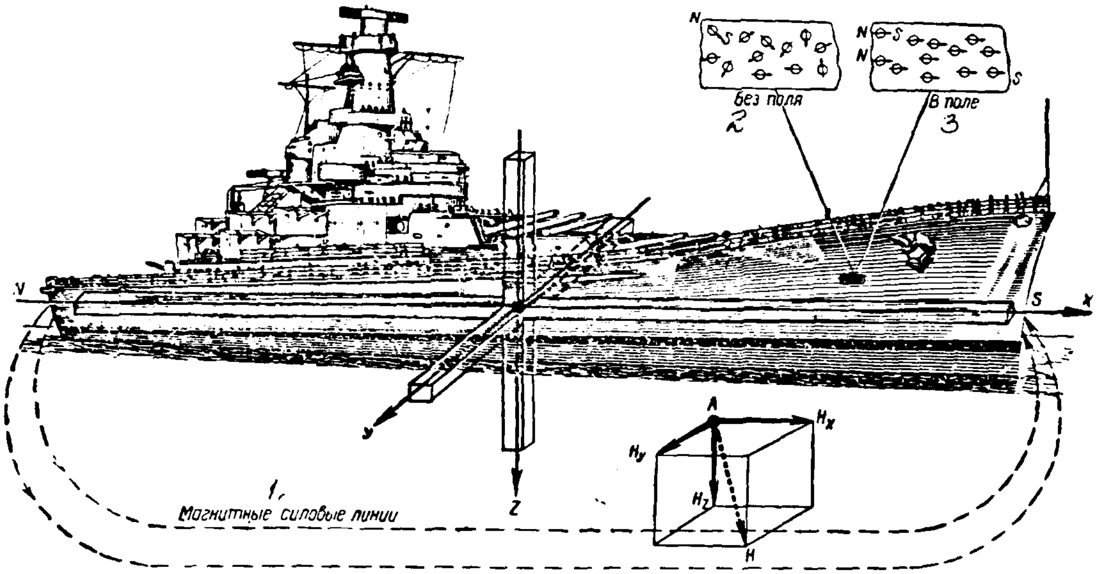

Fig. 21. The magnetic field of a ship according to data presented in a book by Cowie, "Mines, Minelayers, and Minelaying," Oxford, 1949. Key: 1. Magnetic lines of force; 2. without a field; 3. in the field.

Let us draw three mutually perpendicular planes through the hull of the ship (fig. 21): the midship plane(the lateral vertical plane which divides the ship into the forward and stern portions), the center plane, and the /52 horizontal plane plane passing through the waterline; These planes intersect as three mutually perpendicular lines which we will take as the axes of the coordinates. The positive direction of the axes X, Y, and Z are indicated by arrows.

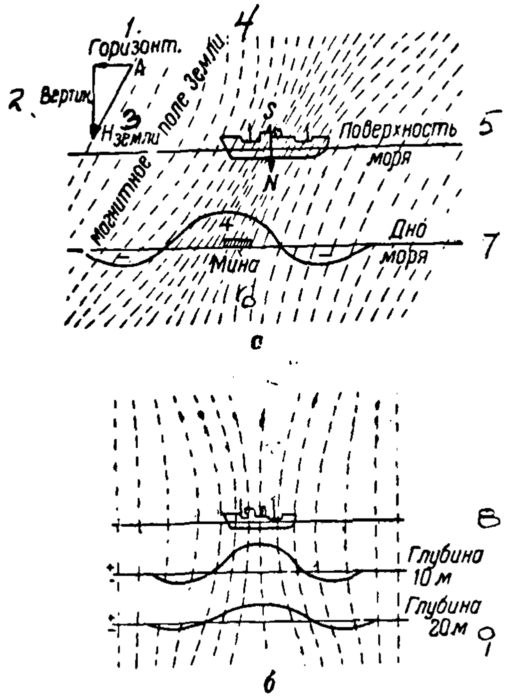

Fig. 22. Distribution of vertical component values of the magnetic field intensity beneath a ship:
a. Magnitude of field at bottom of ocean; b. relationship of field value at the bottom to depth of sea; 1. horizon; 2. vertical; 3. ground level; 4. earth's magnetic field; 5. surface of sea; 6. mine; 7. bottom of sea; 8. depth ten meters; 9. depth twenty meters.

The magnitude of the intensity H at point A can be resolved into the components for these three axes.

The intensity component of the magnetic field H directed along the Z axis is termed the vertical component of the ship's magnetic field. The H_y component directed along the Y axis is termed the lateral horizontal component, and the H_x component directed along the X axis is the longitudinal horizontal component of the ship's magnetic field.

If the direction of the ship's magnetic field component coincides with the positive direction of the coordinate axis the given component is positive.

In the example given in fig. 21 the H_x, H_y, and H_z components of the ship's magnetic field intensity at point A are positive.

The magnetic firing mechanisms in the majority of known foreign mines react to a change in the magnitude of the vertical components of magnetic field intensity (fig. 22).

The electrokinematic diagram of a rather simple model of the M-II magnetic influence firing mechanism of a German mine is shown in fig. 23. This firing mechanism reacts to the vertical component of a ship's magnetic field.

The reacting element of the firing mechanism is the magnetic indicator on whose axis of rotation is secured the contact KП. When the N end (north) of the deflector tilts downward the KП contact approaches the fixed contact KH. When these contacts close an electric circuit is formed through which the current from the electric battery goes to the firing mechanism and causes it to operate.

Apart from the magnetic indicator the basic elements of the firing mechanism are the battery with its chemical source of current, the safety instruments, and the detonator.*

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* A description of the elements in the firing mechanism is offered only in the discussion of the magnetic influence firing mechanism, therefore in the following we will give only a simplified block diagram of firing mechanisms operating on other principles, bearing in mind that their elements operate analogously.

The battery with its current derived from chemical sources consists /54
of series connected galvanic cells. The number of these cells depends on the voltage necessary to insure reliable operation of the firing mechanism circuit during its projected service life. The safety instruments are installed in the firing mechanism for safe handling of the mine on shipboard.

Most safety instruments are designed on the hydrostatic principle. After laying the mine at the required depth the spring which holds the hydrostatic rod is compressed by the pressure of the water on the hydrostatic disk of the instrument and the rod commences to move. As it does so the contacts secured to it which cut in the mine firing mechanism to the electric battery are closed. The hydrostatic arming delay mechanism is designed to switch the mine firing mechanism from the passive to operating condition. This is achieved by switching in the battery to the firing mechanism circuit only after the previously set time period has expired.

A special clock capable of operating over a prolonged period of time is ordinarily used as a hydrostatic arming delay mechanism. This clock begins to run only after the mine has been submerged in the water. The operating time of such a clock can be set to run for from several minutes to several months. Electric contacts which are closed after the set time has expired are connected to the clock mechanism and cut in the electric battery of the mine firing mechanism circuit, putting it into firing condition.

Electrochemical devices, which are more reliable in operation than timing mechanisms and can function over a longer period of time, can be used as hydrostatic arming delay mechanisms. However, the operating cycle

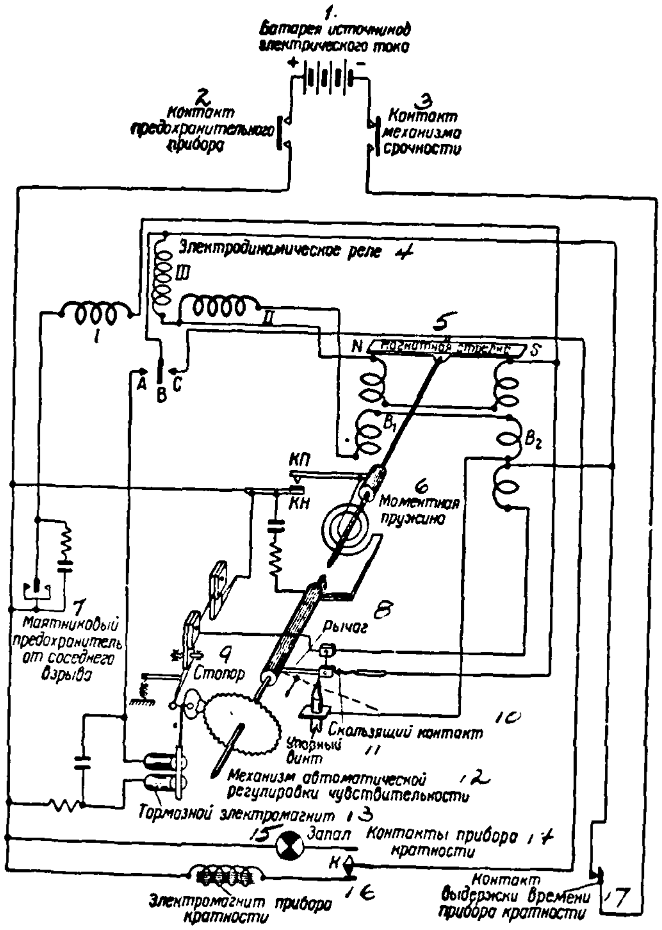

Fig. 23. Electrokinematic diagram of the M-II influence type magnetic firing mechanism of a German mine.

Key: 1. Electric current battery; 2. safety device contact; 3. delay arming mechanism; 4. electrodynamic relay; 5. magnetic indicator; 6. spring; 7. pendulum type safety device against nearby explosion; 8. lever; 9. stopper; 10. steel contact; 11. abutment screw; 12. automatic sensitivity regulator spring; 13. electromagnetic brake; 14. period delay mechanism contacts; 15. detonator; 16. period delay mechanism electromagnet; 17. time element contacts of period delay mechanism.

accuracy in clock mechanisms is greater.

The period delay mechanism is used mainly in bottom models of foreign made influence mines. It is installed in order to make it more difficult to destroy the mine. This device cuts in the mine detonator to the firing mechanism circuit only after the firing mechanism registers that no less than the given number of ship or influence sweeps (artificially created physical field sources) had passed above the mine. During these "dry runs" the mine is not supposed to explode. The period delay mechanism is a special integrating mechanism on which can be set a certain number of blank responses, such as 24, for example. In this case the mine will detonate only on the 25th response of the firing mechanism. /55

Setting the period delay mechanism unquestionably postpones the instant the ship is blown up by a mine. On the other hand, a considerable amount of time and effort is required to destroy mines with period delay mechanisms in which a certain number of blank responses have been set. But the important thing is that the installation in mines of delay mechanisms introduces the element of uncertainty for the enemy since he can never be certain that the mine menace in the swept area has been eliminated.

It is not hard to imagine what effort is required of minesweepers that have undertaken to destroy such mines. Unsuccessful passes above the mines may be made for several months and they will continue to rest on the bottom of the sea, their power supply disconnected by the period delay mechanism. Following that it may be required to make still more passes of unknown number over each mine to exhaust all the blank responses set in the mine period delay mechanism.

However, if one attempts to detonate the mine by exploding plane dropped charges adjacent to it the mine contains a built-in safety element for this eventuality which disconnects the detonator from the firing mechanism.

Special anticountermining devices are used in German mines as protection against disarming and for preserving the operating secret of the firing mechanism.The operating principles of these devices differed. For example, they may be triggered by sounds produced by the frogman who approaches the mine, by the sun's rays, by contact with the mine, or by attempts to raise them.Most often, however, these devices are activated by attempts to remove some screw or device from the mine.

It should be pointed out that a mechanism for automatically regulating its sensitivity is inserted in the magnetic influence firing mechanism. This is attributable to the fact that the magnitude of the earth's magnetic field varies in different places in which mines may be laid. Therefore, the firing mechanism should independently determine the magnitude of the magnetic field at the point where the mine is set and adjust its sensitivity accordingly.

Let us discuss how a mine's magnetic influence firing mechanism operates on the approach of a ship. When the ship moves toward the mine the magnitude of its magnetic field becomes great enough to turn the NS magnetic needle until contact KП touches contact KH. With these two contacts /56 closed the electrical current from the battery positive terminal goes through the closed contact of the safety instrument (in fig. 23 this contact is shown before the mine is set in the open or reference position), the contacts KH and KП, the snap spring and the axis of the lver with sliding contact, the abutment screw, and thence to windings B_2 and B_1. From here the current passes through the windings of the fixed coil II and coil III of the electrodynamic relay to the closed time delay contacts of the period delay mechanism and the hydrostatic arming delay mechanism, and finally to the minus terminal of the electric battery.

In passing through the blocking windings B_2 and B_1 the current produces an electromagnetic field which influences the magnetic needle in the same direction as does the ship's field. As a consequence, the needle compresses the contact KII securely against contact KH.

In the electrodynamic relay windings the current produces an electromagnetic field which deflects the movable coil relative to the fixed coil. Contact B, which is connected with the movable coil, will be closed when the latter is deflected with fixed contact C. On closing these contacts there is produced a current circuit from the electric battery via the winding of the electromagnet of the period delay mechanism. The latter is activated and moves the pin on its scale, thereby counting off one blank response of the mine's influence firing mechanism. Simultaneously with this the hold time contact of the period delay mechanism, which disconnects the minus terminal of the battery from the firing mechanism circuit for 40-45 seconds, is opened.

During this period of time the firing mechanism cannot be triggered repeatedly. This is done so that the firing mechanism may be triggered only once during one pass of the ship (or sweep) and its period delay mechanism may register correctly that the ship or sweep has passed over the mine once.

Following the closure of the time lag contact of the period delay mechanism the firing device is again ready to receive the magnetic field of the next ship. When all the blank responses fed into the period delay mechanism are exhausted contact K will disconnect the winding of the electromagnet from the electric battery circuit and will connect the mine detonator circuit to it. The following response of the firing mechanism will explode the mine.

Induction type influence firing mechanisms in mines. This kind of /57 firing mechanism also responds to the ship's magnetic field. However, it does not respond to the magnitude of this field but to its rate of change during the passage of the ship above the mine (fig. 24). The reacting element in the induction firing mechanisms is not a magnetic needle but an induction coil consisting of a metallic core on which is wound a large number of turns of fine, well insulated wire. The core is usually of metal with high magnetic permeability.

As the ship moves above the mine the lines of force of its magnetic field cut across the windings of the induction coil and induce an electromotive force in them. If a galvanometric relay of high sensitivity is connected to the ends of this winding a current will flow through the loop of the relay. The relay will be triggered and will connect the electric battery through the auxiliary instrument to the detonator, which will cause the mine to explode.

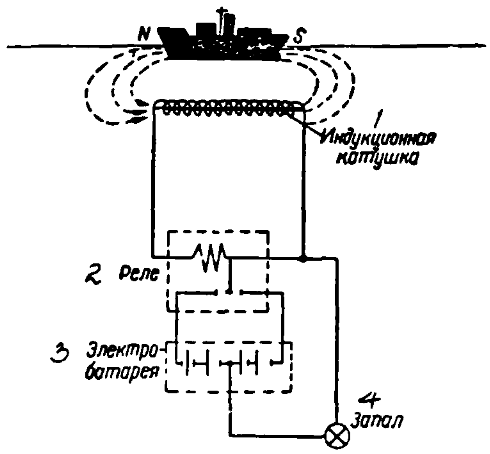

Fig. 24. Block diagram of an induction type influence detonator of a foreign made mine.
1. Induction coil; 2. relay; 3. electric battery; 4. detonator.

The electric circuits of induction firing mechanisms can be complicated. Clever magnetic field changes may be programmed to trigger them; these changes are characteristic only of a ship's field and difficult to reproduce even with the aid of the most modern devices for destroying mines. /58

Induction firing mechanisms, like magnetic firing mechanisms, are equipped with period delay mechanisms and arming delay devices.

A ship's acoustic field. The ship is a powerful source of noise. The noises are created from the operation of numerous mechanims inside the ship's hull. Vibrations and oscillations of the ship's engine supports are transmitted through the ship's hull to the water. A ship's propeller rotating in the water at great speed produces a powerful noise. As a ship moves, the water current flowing about its hull and the ocean waves produce great noises. The noises from a ship are propagated a considerable distance and produce an acoustic field about it.

The aqueous space in which the acoustic pressure forces are detected is called the hydroacoustic field but in our account we shall refer to it as the acoustic field.

The magnitude of the acoustic field is measured in physical units known as bars. One bar is a magnitude of acoustic pressure with a force of one dyne acting upon an area of one square centimeter. A dyne is the force which imparts to a mass of one gram an acceleration of one cm/sec^2.

To perceive this magnitude it will be recalled that the pressure on the human ear drum in ordinary conversation is registered as one bar.

We shall now consider how the formation of acoustic pressure occurs in water from the effect of some source of noise, such as the oscillation of the plating in the underwater part of the ship's hull.

If we consider an individual portion of this plating it can be compared with a steel membrane secured on the edges. One side of this membrane faces the inside of the hull and the other side is in contact with the water (fig 25).

If this membrane is caused to oscillate, for example if a blow is struck against its left side, than on bending to the right it will create in the water layer adjacent to it a so-called excessive pressure or compression. When the membrane is bent to the left by resilient elastic forces a "rarefaction" is created in the water layer adjacent to it.

Oscillations caused in any one spot by the water medium are not limited to that place but spread in all directions. The extension of "compressions" and "rarefactions" is a longitudinal wave-like movement during which the particles of water will oscillate about its position of equilibrium. /59

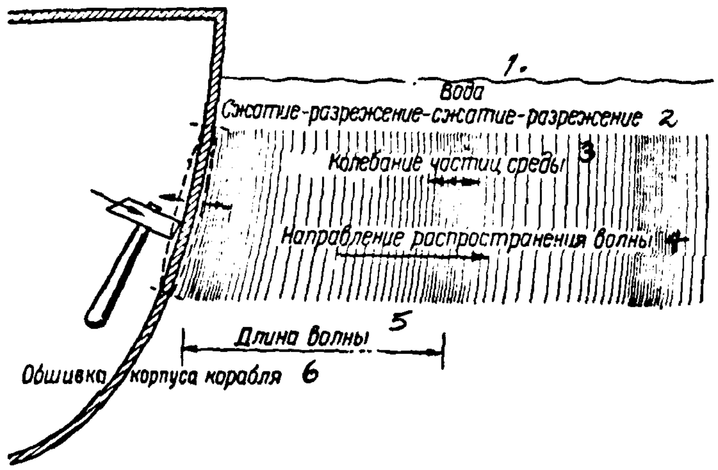

Fig. 25. Formation of acoustic waves when a portion of a ship's hull oscillates.
1. Water; 2. compression-rarefaction-compression-rarefaction; 3. oscillations of medium particles; 4. direction of propagation of waves; 5. length of wave; 6. ship's hull plating.

Each particle of water with inertia transmits oscillations to the neighboring particle with a certain amount of delay, therefore the acoustic pressure is distributed into the surrounding medium as a longitudinal wave moving at a certain rate.

The mean rate of propagation of acoustic waves in water is about 1500 meters/sec. In water these waves spread much more slowly: the average speed of motion is about 330 meters/sec. The number of complete oscillations completed in one second is known as the frequency of oscillations. The accepted unit of frequency is a physical magnitude known as a hertz; it is the frequency whereby one full oscillation occurs in one second. For example, if 1,000 complete oscillations take place in one second we say the frequency is equal to 1,000 hertz or one kilohertz.

To get some idea of the range of acoustic frequencies existing in /60 nature it will be pointed out that the human ear is capable of perceiving and transmitting to the brain as audibly sensed sound only those oscillations which range in frequency from 16 hertz to 20,000 hertz -- the range of audible frequencies. Oscillations with a frequency below 16 hertz (infrasonic) cannot be heard by the human ear -- this is the low frequency band. Frequencies above 20,000 hertz (ultrasonic) are likewise imperceptible to the human ear -- this is the high frequency band.

If the source radiates acoustic oscillations on one frequency these oscillations are heard as a definite sound. An increase in the frequency of scillations is perceived as an increased tone in the sound.

If the source or several sources produce acoustic pressure oscillations at all frequencies the overall result is perceived as noise. The ship is the source of noise in a broad range of frequencies. The intensity of noise in the band of audio frequencies of from 100 hertz to 5,000 hertz is especially great. Ship's noises of different types have their individual peculiarities. In the case of fast ships the higher frequencies are more intensively manifested, and in the case of slow ships, e.g. transports, the lower frequencies are more prominent.

The noises of individual mechanisms are also different. For example, the noise of an electric motor has sharply expressed high frequencies, while pumps in the hold and the diesel engine exude noises in the low frequency band. One source of low frequency waves is the basic vibration of large areas of the ship's hull. Low frequency oscillations can be propagated in water through very great distances. This quality of low frequency oscillations is utilized in the construction of foreign influence mines.

Audio frequency oscillations are produced in large part by the different ship's mechanisms and engines and comprise the most concentrated part of the noise spectrum of all classes of ships. Audio frequencies are propagated through great distances from ships, hence they are very widely used in influence firing mechanism.

The idea prevails that silence dominates the underwater depths. This is not so. The underwater region is distinguished by its especial "sonorousness", and acoustic waves are capable at great distances to warn a mine about the approach of a ship. Fig. 26 shows a sample curve of changes in acoustic pressure magnitude as a function of a ship's distance to the noise receiver.

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As we can see from the diagram the greatest pressure is observed at the moment the ship passes above the receiver. The magnitude of acoustic pressure compared with the magnitude of the constant hydrostatic pressure in the deep is insignificant. For example, whereas at a depth of 15 meters the hydrostatic pressure is about 1.5 million bars, at this same depth the value of acoustic pressure produced by a ship may amount to a total of only several hundred bars. It is possible to distinguish such a small acoustic pressure against the background of greater magnitudes of hydrostatic pressures because audio receivers react only to pressures that change in magnitude; they do not react to the constant hydrostatic pressure, regardless of how great its magnitude.

In passing over from one medium to another the greater part of the oscillating energy is reflected from the interface surface and only a small part of the energy penetrates into the second medium. For example, when audio frequencies from the air pass into the water only about one one-thousandth of the total audio energy penetrates into the water, therefore the different sounds appearing in the air have very little influence on receivers located under water. The reflections of acoustic oscillations off the bottom and the surface of the sea are very intensive.

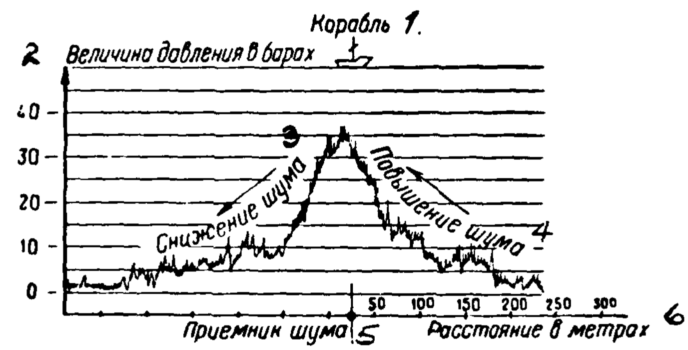

Fig. 26. Curves of changes in magnitudes of acoustic noise pressure as a ship approaches the receiver (according to the German journal "Deutsche Akademie der Luftfahrtforschung," June,1942) Key: 1. Ship; 2. pressure magnitude in bars; 3. reduction in noise; 4. increased noise; 5. noise receiver; 6. distance in meters.

The main source of high frequencies (ultrasonic) is the propeller. The propeller radiates high frequencies with especial intensity when it /62
begins to cavitate at high rotational speeds in water (Propeller cavitation is a phenomenon associated with the formation in the water of low pressure cavities on the blades of a rapidly rotating ship propeller). In the process there are formed numerous low pressure "bubble" which, on breaking loose from the propeller blades, are carried away by the current into the region of increased hydrostatic pressure and are instantaneously contracted, i.e. they "collapse" and disappear. The process of such disappearance of 'bubbles" is accompanied by a unique type of hydraulic shock. The application of a large number of such shocks results in a characteristic hissing sound --

a high freeuency noise which attains marked intensity at high speeds of propeller rotation.

As high frequency acoustic oscillations spread they encounter considerably more obstacles along their path than is true of low frequency and audio oscillations. Even small organisms, water bubbles, and inorganic particles, of which the ocean has so many, are obstacles.

In overcoming these obstacles along its path high frequency oscillations are partially reflected from them and partially absorbed, and only an insignificant amount of energy penetrates through. In this connection the boundaries of the water space in which high frequency oscillations are propagated can be conceived as being in the form of a loop limited by the interior part of the cone whose axis passes through the ship's propellers (fig. 27). As a result of this directivity characteristic of high frequency noise radiated by the ship's propeller influence mines are adquately prepared to differentiate by this sign the noise of ships from all other interferences and to explode underneath the propellers.

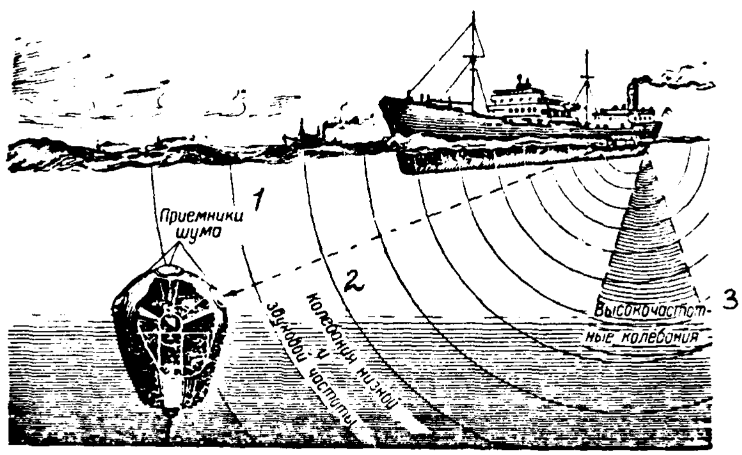

Fig. 27. Acoustic field of a ship and a sketch of its effects on an acoustic influence mine.
Key: 1. Noise receivers; 2. low and audio frequency oscillations; 3. high frequency oscillations.

Acoustic type influence firing mechanisms of mines. For an acoustic firing mechanism to operate (fig. 28) it is necessary, first of all to convert the oscillating movements of the receiver membrane into electrical signals. This can be done with the aid of a special electromechanical device -- the hydrophone.

While the hydrophone membrane is in the idle state a direct current flows through the carbon powder in the hydrophone capsule and the primary winding of the transformer; that current does not produce a voltage on the secondary winding of the transformer.

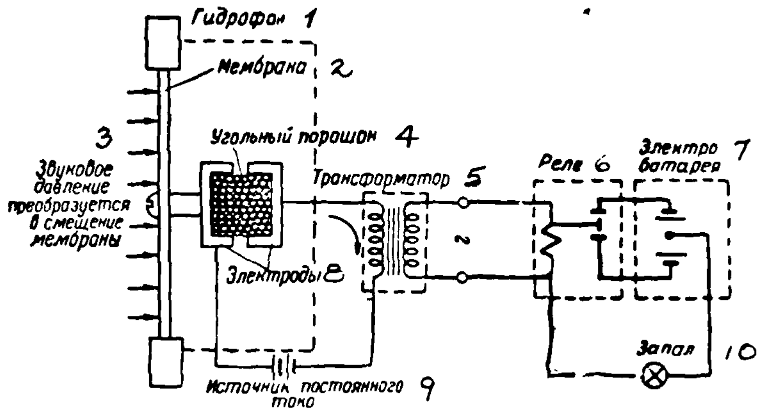

Fig. 28. Block diagram of an acoustic type influence firing mechanism in a foreign mine

Key: 1. Hydrophone; 2. membrane; 3. audio pressure is converted into motion of the membrane; 4. carbon powder; 5. transformer; 6. relay; 7. electric battery; 8. electrodes; 9. direct current source; 10. detonator.

When the acoustic pressure acts upon the membrane the latter begins to oscillate. As the membrane vibrates the capsule electrode connected to it compresses the carbon powder and pulls away away from it. When the /64
powder is compressed the carbon grains are pressed tightly against one another and the number of points of contact between them increases thereby reducing the electrical resistance of the powder. When the electrode moves in the opposite direction the carbon granules separate and the electrical resistance increases; therefore, during each period of oscillation the strength of the current in the electrical circuit increases and decreases.

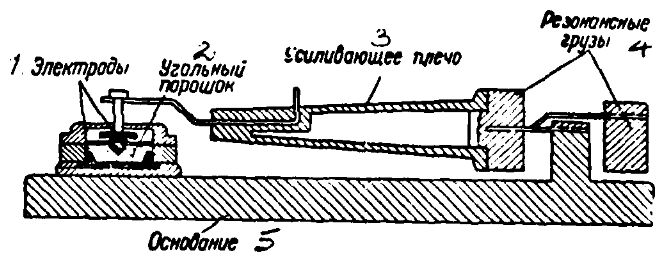

Fig. 29. Vibration type acoustic receiver of the German C-type mine

Key: 1. Electrodes; 2. carbon powder; 3. reinforcing shoulder; 4. resonant weights; 5. base.

In this case the alternating current passes through the primary winding of the transformer producing a voltage on the secondary winding which is then used in the mine firing mechanism circuit as a signal warning it of the

the approach of a noise source. In this case a current will flow through the relay loop; the relay is activated thereby and cuts in the electric battery through the auxiliary instruments to the detonator which causes the mine to explode.

Carbon hydrophones are ordinarily used for listening to the sounds of ships in the audio frequency band. Acoustic recivers of a more complex design are used for the reception of frequencies above and below the audio band.

The vibration type receiver shown in fig. 29 is secured to the inner wall of the mooringmine shell and senses its vibrations when it is acted upon by the noise of the ship. The foreign literature carries information to the effect that mines in the high frequency band are not limited merely to "listening" but in turn can "hum" producing high frequency oscillations so as to create an echo from the ship's hull and thereby be certain that a ship is actually located over the mine. But in doing so they run the risk of being detected by the ship's sonar bearing indicators.

If the ship succeeds in picking up the noise of a mine operating mechanism it will attempt every measure to destroy or avoid it.

Thus, there can be a duel between ships and underwater automatic devices of mines which either "make a noise" to produce an echo everywhere or "are silent" and hear their own echo.

Influence mines whose operating principle is based on the varied properties of the acoustic field have certain advantages over the magnetic mines; the acoustic field spreads over considerably greater distances than the magnetic field, therefore it permits one to construct firing mechanisms with an extensive operating zone. In addition, the ship can easily be demagnetized but it is difficult to "de-noise." For this very reason most influence firing mechanisms used in World War II have been built on the acoustic principle of operation or contain an acoustic receiver in one of the channels of the combination type influence firing mechanism. In such case the simultaneous action of several fields of the ship or their action in a certain sequence are required to explode the mine.

The ship's hydrodynamic field. When in motion a ship displaces a certain volume of water. Simultaneously with this there appears a free space behind the stern of the vessel. The liberated space carved out on the water surface by the ship's hull and which is similar to a "channel" is immediately filled in by the surrounding water.

Therefore, as the ship moves through the water there seems to be two new currents: the displacement current in the bow portion of the vessel and the "refill" current in the stern portion.

The flow of water from the source of displacement to the filling area brings about a re-distribution of velocities of particles in the water surrounding the vessel. As a result, the hydrodynamic pressure increases in the bow area of the ship, decreases under the center portion of the ship's hull, and again increases in the stern portion of the ship (fig. 30b).

Pressure changes in the water with the movement of the ship can easily be measured by means of instruments resembling ordinary manometers. /66

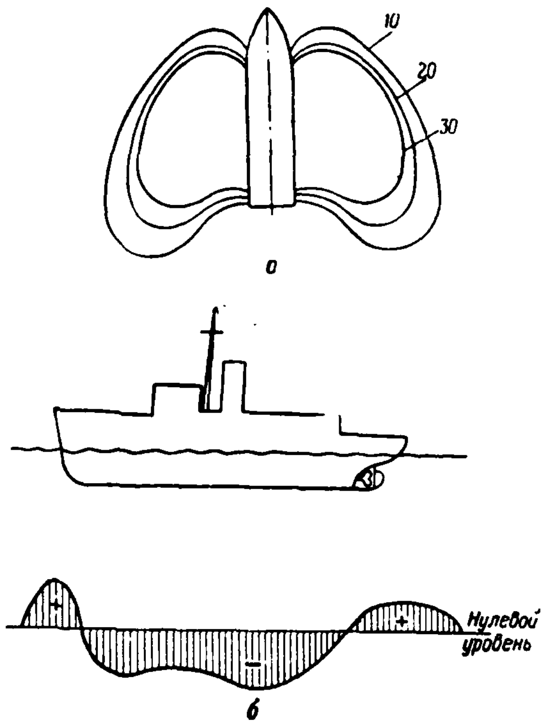

Fig. 30. Changes in the magnitude of the hydrodynamic field of a ship (According to data by the Journal La Revue Maritime, 1956)

a. Distribution of reduced hydrodynamic field pressure in a horizontal plane around a ship in millimeters of water column; b. characteristic curve of change in hydrodynamic pressure in vertical plane underneath a ship.

Fig. 30a. describes the lines of equal pressure of a hydrodynamic field of a ship displacing about 1200 tons. These measurements were made at a depth of 8-12 meters during the passage of a ship at a speed of 9 knots.

The hydrodynamic field extends laterally from the ship to some considerable distance. For example, according to a 1956 issue of La Revue Maritime, a French journal, a cruiser with a displacement of about 10,000 tons traveling at a speed of 25 knots in an ocean area with a depth of 12-15 meters /67 can cause a reduction in pressure by 5 mm of water column even at a distance of 500 meters to the right and left of its position.

The magnitudes of the hydrodynamic fields of different ships depends on their speed and displacement. With an increase in the speed and greater lateral section of the immersed portion of the ship's hull changes in the dynamic pressure are more pronounced. In addition, with a reduction in the depth of the area in which the ship is sailing the bottom hydrodynamic pressure created by it increases.

Hydrodynamic firing mechanisms. The hydrodynamic pressure receiver of an influence firing mechanism in the Oyster type foreign built mine consists of two compartments, A and B (fig. 31). Compartment A is made of an elastic material, such as rubber, for example. Compartment B has a constant volume and is made of metal; in the center it has a thin flexible baffle, the membrane M. The membrane divides comparment B into two spaces which are joined together by channel ҇ which has a very small diameter. The channel serves to equalize the pressures slowly in the spaces on both sides of the membrane.

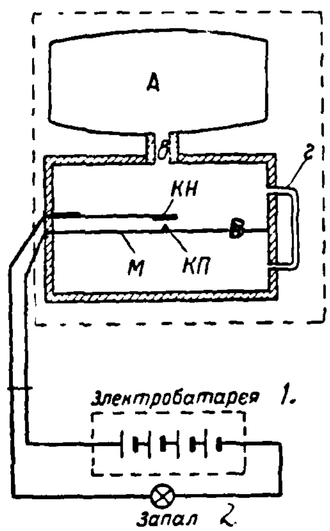

Fig. 31. Block diagram of a hydrodynamic influence type firing mechanism in the Oyster, a German made mine.
Key: 1. Electric battery; 2. detonator.

The moving contact КП is secured to the membrane, and the fixed contact is secured to a special support. The space between the contacts is very small -- of the order of tenths of a millimeter.

The elastic compartment is directly in contact with the water, therefore when the mine is submerged this chamber has decreased volume due to the water pressure.

Because of the decreased volume of the elastic compartment A the pressure in the upper hollow of the metallic chamber B increases. Under the /68
influence of this pressure the membrane M will be bent downward and the space between the contacts KH and КП will increase.

After the mine is submerged and lies on the bottom the pressure on both sides of the membrane begins to equilize slowly via channel γ.

When equilibrium attains in the system the membrane, which is under the influence of elastic forces, returns to the middle (original) position. As this takes place there will be observed an increase in pressure in all compartments whose magnitude depends on the depth where the mine was laid.

When a ship passes over the mine there is a rapid decrease in the internal pressure on the elastic chamber. As this takes place the pressure in the spaces of chamber B which are divided by a membrane fails to become equalized through channel γ which has a small diameter and the membrane, which has bent upward, closes contacts KH and KП. The contacts are switched into an electric circuit and feed a singla for the further action of the mine firing mechanism. If the wires from the contacts are switched into the electric detonator circuit the current from the electric batteries, on closing this circuit, will pass through the detonator which then explodes the mine.

We have considered the simplest version of a pressure receiver. More complex receivers can react to a specific program of change in increased and reduced pressures observed with the passage of a ship.

Tidal flow and waves can produce marked changes in the hydrodynamic pressures at various depths. For example, under certain conditions the length of ocean waves and their amplitude attain such magnitudes at which bottom hydrodynamic pressures become completely commensurable in magnitude and duration with pressures that develop when a ship has passed. Accordingly, hydrodynamic receivers are usually used in circuits of combination type influence firing mechanisms (in combination with acoustic, induction, and other kinds of receivers) to provide reliable protection for mines against pseudo triggering.

New operating principles in influence type mine firing mechanisms. /69
Influence firing mechanisms can be triggered not only by a ship's magnetic, acoustic, and hydrodynamic fields but also by other fields and physical phenomena appearing in the water when a surface vessel or submarine passes by.

Ideas are set forth in foreign naval literature about the possibility of developing new kinds of firing mechanisms the basis of which will be highly sensitive receivers capable of reacting to changes in temperature, the composition of the water during the passage of the ship over the mine, luminous and optical changes, variation in the intensity of cosmic rays, etc.

La Revue Maritime carried an article in 1956 which contained a table in which were shown possible types of action by a ship on mine firing mechanisms. Temperature changes with the passage of a ship above a mine are due to the fact that it radiates thermal energy into the water. But these changes can only be noted at distances of only several meters away from the ship because water is a poor conductor of heat.

The composition of water after the passage of a ship can change due to the discharge into the water of oils, gases, and the like from the different machinery. Obviously, ships which have jet engines for their power plants, as well as wngines which operate on hydrogen peroxide will leave a distinct wake behind them.

Luminous optical changes on the passage of a ship are due to the fact that during daylight the vessel produces an area of reduced illumination or shadow in the water beneath it. By this shadow the luminous and optical receiver of an influence firing mechanism of a mine can establish that a ship is located above it.

Distribution of the radiant energy of light waves in water depends, primarily, on its transparency, therefore the depth of light penetration in different waters varies. The optical properties of natural waters change within very broad limits. The waters of the ocean are very transparent, while coastal waters and river waters are very turbid.

Cosmic rays are the invisible strangers from outer space. They consist of a flow of charged particles. Possessed of collosal energy, cosmic rays penetrate to the earth's atmosphere, reach the surface of the earth, and penetrate into the depths of the waters. According to La Revue Maritime, these rays can readily be detected with the aid of special apparatus at a depth of about 60 meters. Influence firing mechanisms of "cosmic mines" utilize phenomena associated with the fact that a ship in passing over a mine creates underneath its bottom an area of reduced intensity of flow of cosmic rays or a "cosmic shade." Reacting to this shade, the influence firing mechanism of the mine can establish that a ship is present above it and explodes the mine. Mines of this type can operate independently of the time of day or night because cosmic rays are constantly arriving from outer space. /70

Information is lacking in the table as to the possibilities of utilizing radiowaves for activating influence firing mechanisms. This is explained, obviously, by the fact that radiowaves cannot readily penetrate into the depths of the sea, and that their penetration into water deteriorates as the frequency increases. However, it is known that attempts have been made to use radio for underwater communications. In these cases powerful radio sets were used which operated at very low frequencies.

Given the present state of scientific and technical thinking it has become possible to utilize practically all the known physical fields for influence firing mechanisms of mines.

In recent years new instruments have been produced in the United States and Britain for use in measuring magnetic, acoustic, hydrodynamic, cosmic, and other fields; noiseless launch-borne test benches have been developed to measure distant acoustic fields under various hydrological conditions. In addition, special soundproof basins have been built and equipped with high frequency gear for measuring infra and ultra sounds.

The physical fields of ships contain many other properties as yet unstudied which can be identified and applied to mine production practices. Therefore, the problem of studying the physical fields of ships is very important and is of great significance in the production and development of new types of mines, as well as in developing means to counter them.

DEALING WITH MINES

Mines are dangerous underwater weapons and should be combatted by all possible means. Modern anti-mine defenses include measures directed toward combatting the carriers of enemy mines, insuring continued observation of areas of possible minefields, searching for mines, and reconnoitering minefields which have been secretly planted by the enemy. In addition, anti-mine defenses call for the destruction of mines and producing individual defenses for ships. /71

Active warfare against enemy minefields consists in destroying carriers of mines at their bases, while en route to the areas to be mined, as well as while they are laying mines.

Anti-mine observation insures the timely detection of mine carriers and provides an opportunity to counter them and to determine the time and place where the mines are planted. With this aim in view the most important sea lines of communication are equipped with special radar equipment for the detection of airborne carriers and the places where mines were dropped in the water. Acoustic devices are placed under water for the purpose of detecting mine-laying submarines.

The search for mines is conducted to determine in which areas the enemy has secretly planted minefields or placed individualmines and to insure that ships are deflected from being on a collison course with them; another objective is to facilitate the destruction of mines.

During World War II various search devices were utilized by frogmen to locate mines, including probes, metal locators, etc.

Attempts were undertaken in the United States and Britain after the war to locate mines by means of metal locators towed by ships. The locators created their own electromagnetic field which, in the presence of mines with a steel shell, was distorted. Distortion of the field was registered by instruments carried in the ship. However, it was not always possible to pick up mines by this method.

In recent years the foreign press has reported ever greater successes in the development of mine searching equipment. It was suggested that frogmen equipped with special instruments be more widely used. Apparently the employment of frogmen to search out mines on the ocean bottom proved to be the more simple and reliable method. In addition, the frogman can evaluate a situation and, if required, can destroy the mine. In doing so, the most complete assurance can be obtained as to the absence of any mine menace in the inspected zone.

In attempting to destroy mines using various special type mine /72
destroying devices one does not know whether there is a mine on the bottom or not. After a minesweeper has made several sweeps over a mine in order to remove all the blank responses inserted into the period delay mechanism there is no complete assurance that all mines have been swept.

Success in the use of the various means for locating mines depends on the conditions in which one has to search for mines, as well as on the capacity of the mines themselves to avoid detection or actively to counter detection.

Fig. 32. Searching for mines from the air by helicopter

The same French magazine indicated that through the use of sonar equipment, for example, it is possible to detect the presence of only those mines which are floating at not excessive depths. It is very difficult for sonar detection gear to locate a mine on the ocean bottom, especially in those cases where it is covered with a layer of silt or marine growth.

For seeking out mines foreign navies are making constantly greater use of underwater television equipment from surface vessels sailing at slow speed, as well as from helicopters and dirigibles. The method of searching out mines from the air is comparatively safe for the observers (fig. 32). La Revue Maritime cites information about various types of searchers operating on the induction, acoustic, and other principles.

However, to insure safety in the channel through which the ship is to pass preference has been shown, thus far, for the use of divers to make underwater investigations. Accordingly, the foreign press places great store in the development of equipment for the rapid transportation /74
of the diver under water and supplying him with instruments for detecting mines at great distances.

Individual types of motor equipment (fig. 33) are used as means for the rapid transfer of a diver; the speed and direction of movement of the equipment is controlled by the diver. There are also several designs of underwater vanes or sleds for divers which it is proposed to tow underwater behind a ship or by a helicopter. The results of observation will be transmitted by the diver via telephone to the ship towing him. La Revue Maritime also states that in the foreign fleets there have been designed several models of midget submarines and equipment for underwater investigations equipped with gear for optical, acoustic, and magnetic detection of mines.

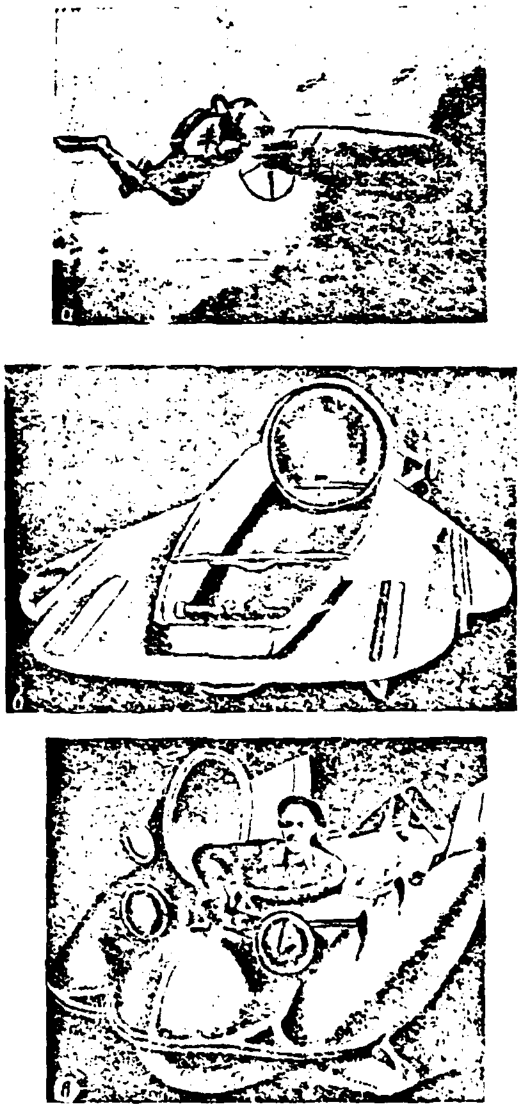

Fig. 33. Equipment for moving divers and for making underwater investigations in searching for mines.
a. Apparatus for moving divers; b. underwater sled towed behind a ship; c. apparatus for underwater research. /73

Minesweeping. Destruction of mines is one of the more important measures in an anti-mine defense system; it is carried out for the purpose of eliminating the mine menace or reducing it in the ship's navigating area. The task of destroying mines at the present time devolves mainly on a special class of surface vessels -- the minesweepers. Aircraft, helicopters, and dirigibles can be enlisted for this purpose also.

The main equipment used for destroying mines is a special device called the sweep. Sweeps are subdivided into the contact type used for sweeping moored mines and the influence sweeps used for sweeping bottom planted influence mines. There are, in addition, sweeps that are used for collecting floating mines.

In the process of developing sweeping equipment in the battle between the mine and sweeping equipment victory has alternately shifted from one competitor to the other.

The most reliable means for sweeping moored mines are considered to be devices which cut or destroy the mooring line with an explosive charge. The cutting sweep, used in single sweep towing (fig. 34), is equipped with a so-called otter board; this device deflects the sweep to one sidein order to encompass a more extensive area. The sweeping portion is provided with cutters which sever the mooring line of the mine to be swept. In this case the mine shell floats to the surface and is then readily destroyed. But the mooring rope can be protected against the sweep and then becomes /76 extremely difficult to cut. During World War II the Germans jacketed the mooring rope with steel tubes or used steel chains instead of the conventional mooring line.

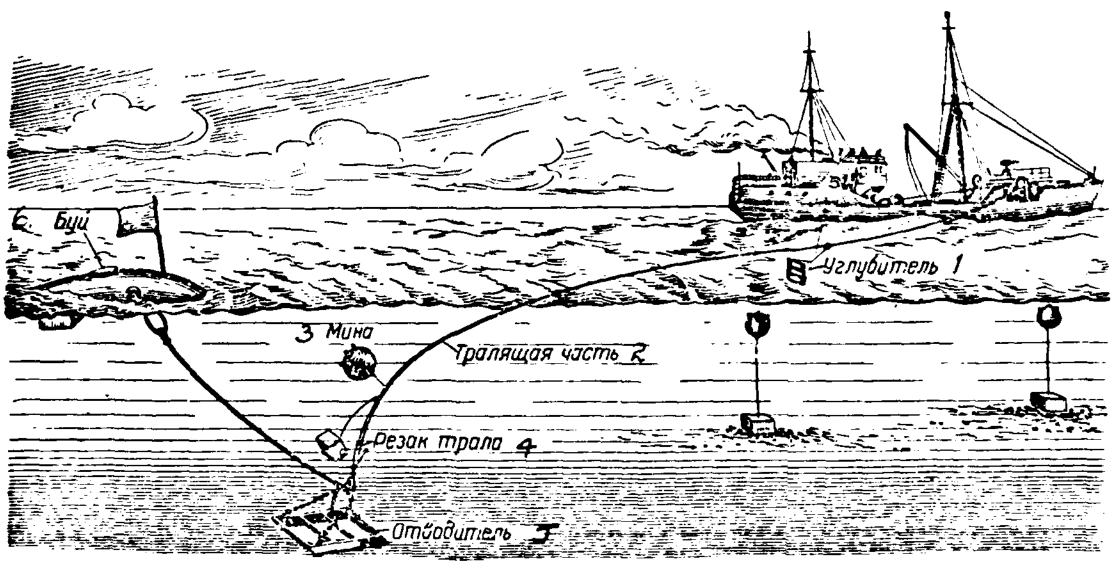

Fig. 34. British cutting type trawl
1. Depressor; 2. sweeping part; 3. mine; 4. sweep cutter; 5. otter board; 6. buoy.

Bottom influence mines can be swept only by influence type sweeps whose operating principle is based on the capacity of the sweep to reproduce the physical field which to some degree resembles the physical field of a ship or to create an effect in the water environment similar to that of a ship passing by (shadow, wake, etc).

During World War II magnetic sweeps were used for sweeping influence type magnetic mines. The German type magnetic sweep, for example, consisted of a magnet or electromagnet towed behind the minesweeper at a safe distance (fig. 35a). The size of the field of such a sweep should be considerably greater than that of the largest ship in order to produce an explosion of even low sensitivity mines which respond to a magnetic field.

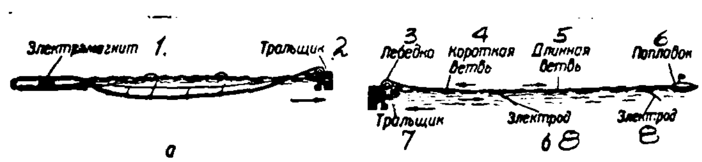

Fig. 35. Sweeps for destroying influence type magnetic and induction type mines.
Key: 1. Electromagnet; 2. minesweeper; 3. winch; 4. short branch; 5. long branch; 6. float; 7. minesweeper; 8. electrode.
a. German electromagnetic sweep; b. open electromagnetic U.S. type L sweep.

In sweeping for induction type mines the Americans developed an open electromagnetic L-sweep (fig 35b) which is capable of reproducing a magnetic field whose magnitude and rate of change can be regulated by a certain program necessary for sweeping mines.

Acoustic sweeps are powerful radiators of noise at different frequencies. The operating condition of the radiators is also regulated in accordance with a certain program.

Floating mines are swept using a special net type sweep similar to those used in fishing. All of the sweeps mentioned can be used not only on minesweepers but helicopters, as well. According to foreign press reports tests conducted in the United States involving heavy helicopters for towing sweeps have demonstrated that such craft can indeed conduct sweeping operations even in very rough seas when minesweepers are unable to leave port. /77

Mine bumpers are ordinarily used for destroying unknown types of mines.

These are ships of special design or rebuilt cargo vessels on which special equipment is installed to produce powerful magnetic, acoustic, and other fields; additional watertight bulkheads are constructed to improve its ability to remain afloat when damaged. A mine is exploded by the passage of a mine exploding vessel in its vicinity. During such sweeps the personnel are usually housed in the upper compartments of the ship and in places best protected against the effects of an exploding mine.

During World War II one of the more important tasks in anti-mine defense was to provide individual protection for ships against influence mines. This question has not lost its importance even now.

We know from foreign naval literature that ships have various devices for protection against mines. By way of example La Revue Martime reports that in order to protect a ship against influence mines at the present time the physical fields of a ship are artificially reduced or intensified to magnitudes at which the influence type firing mechanisms of mines designed for a normal field intensity will not be triggered at all or will be activated at some distance away where the explosion of a mine is not dangerous to the ship. In addition, special ship towed devices are used which are supposed to deflect mines away from the ship's hull, or which explode influence mines a safe distance away.

However, the presently known individual protective devices cannot insure complete safety to ships against exploding mines.

Suffice it to say that especially sensitive mines can operate against ships with a reduced field and special low sensitivity mines can operate against ships with reduced field intensities. Paravanes are not very effective against new types of mines and in some instances they even have a negative effect because some mines explode as soon as they are embraced in the paravane. Mine fields are usually made up of different kinds of mines.

The number of different combinations of mine firing mechanisms designed to respond to the effect of several different fields of a ship is literally infinite, hence it is very difficult in practice to divine the many /78
possible variations of mines that could be used and insure adequate protection for a ship. Even special type minesweepers and barrage breakers are not capable of carrying at the same time all the equipment necessary as protection against mines or to destroy them.

EXPLOITS OF NAVY MINE SPECIALISTS

At the beginning of the Great Patriotic War despite the fact that Germany had a variety of mines at the very outset and the fact that their submarines, aircraft and surface vessels planted tremendous numbers of mines in the seas, rivers, and lakes, they nevertheless failed to disorganize Soviet shipping and could not immobilize naval operations. The contributions of our naval mine experts in this regard were by no means modest; they performed many heroic deeds in carrying out their assignments.

The duty of the mine expert is by no means an easy one; it is fraught with extreme danger. The saying goes that these people can make a mistake only once. The smallest error can lead to the explosion of a mine. These experts should have mastery of their specialty, be capable of disarming various kinds of mines, possess ingenuity in disarming mines of unknown design, and be daring and resourceful. Precautionary measures should always be uppermost in his mind. Haste and indifference could prove fatal. Disarming new types of enemy mines was a very important kind of mine reconnaissance during the war period. Not knowing the construction of the mine it was impossible to know whether the tactical procedures and mine sweeping methods were correct. In addition, the enemy frequently changed the system of firing mechanisms in the mines.

At the beginning of the war when there were still no solid information as to the type of mines planted by the enemy, M. I. Ivanov, a mine specialist attached to the Black Sea fleet, successfully disarmed a German magnetic mine, thereby solving its secret.

In the fall of 1941 in the Novorossiysk region a German aircraft had planted some bottom mines. The point of drop had been precisely determined. Divers descended to the sea bottom, located on of the mines /79 and, carefully securing a long line to it, towed the missile away to a shallow area , and then hauled it ashore. The mine proved to be of unknown design. To determine whether it was equipped with some kind of delayed action device it was isolated on the shore. Following that, mine specialists attached to the Black Sea fleet and master engineer-electrician E. T. Lishnevskiy and Sr. Lt. S. I. Bogachek proceeded to disarm it. Exercising every care these specialists extracted the internal workings using special non-magnetic tools. The secret of the mine was revealed -- it was an acoustic type mine.

On the following day the divers recovered a second such mine. Lishnevskiy and Bogachek decided to disarm it immediately. However, as they approached the mine there was an unexpected explosion and both of these brave mine specialists were killed. It seems that the Germans had begun to use "booby traps" which exploded the mines as they were being disarmed.

On the Black, North, and Baltic Seas and on the Volga River, which had a flow of freight during the war equivalent to more than ten railroad lines, courageous naval mine experts disarmed many new models of enemy mines, each time risking their lives in the cause of victory. However, the enemy continue to grow more and more crafty. The fascists began to install new types of decoy devices which were extremely difficult to deal with. These instruments exploded the mines not only while they were being disarmed but also when attempts were made to lift them off the ground or to move them about.

In 1942 the situation in the Sevastopol area was very grave. They enemy strived with might and main to disrupt communications between the besieged city and the sea and laid down mines of an unknown type. The naval experts were confronted with the difficult task of first finding a mine and then disarming it in order to know how to cope with the menace. In these difficult circumstances G. N. Okhrimenko, an officer of the

Black Sea fleet, performed a very brave deed.

A mine was found during a diver's inspection of the sea bottom. There arose the question of how to disarm it. An attempt to raise a similar mine resulted in an explosion during which experienced mine specialists were killed. It was then decided to disarm the mine under water. /80 Officer Okhrimenko volunteered to perform this task. After learning how to dive he and some diver specialists proceeded with the task at hand. Several times during the week Okhrimenko dove to the 20-meter depth to combat the "infernal machine" single handedly -- a weapon which could go off any moment at the slightest mistake. Enemy artillery was firing upon the diver utility craft, which was hit several times. There was every danger that the air hose supplying the diver with atmospheric air would be damaged. However, Okhrimenko continued with his dangerous task and soon disarmed the magnetic acoustic mine.

Fleet mine specialists performed numerous heroic exploits in laying mine fields and sweeping the seas for mines. Minesweeping under combat conditions is an extremely dangerous operation for minesweeper personnel who are always in the forward echelon, exposing themselves to the risk of death from exploding mines and torpedoes. In addition, they can always be fired upon by enemy ships and attacked by his planes.

Vast areas were mined during the war. To sweep these areas there was often a shortage of personnel and equipment, and therefore minesweepers could sweep, though not without great difficulty, only the more important channels, thereby insuring the movement of naval craft and freighters behind them.

The service operations of mine specialists did not cease with the end of the war. They are continuing in this effort even to the present time. Here is a sample incident that occurred in 1953 in the Gulf of Finland. A German influence type moored mine brokeloose during a storm and drifted to the shore of one of the islands.

The task of disarming the mine was entrusted to LTC Alyuksyutovich and Warrant Officer Melnitskiy. They were obliged to work under very difficult conditions. Standing waist deep in cold water these mine specialists proceeded with the disarming project. With difficulty they succeeded in loosening the rusted screws of the safety device and tried to extract it from the orifice, but to no avail. The mine was still dangerous. The impact of the seas against the shell of the mine triggered the firing mechanism devices: a definite click was heard and an explosion at any moment appeared a possibility, hence the importance of working fast. With superhuman effort the specialists pulled out the flange of the safety device. Alyuksyutovich extended his arm into the opening, broke off the wires leading to the detonator, and thereby disarmed the mine. /81

There are, in addition, cases wherein floating mines suddenly appeared in areas that had been thoroughly swept before. The following is one such incident.

Many mines were destroyed while sweeping in the Gulf of Narva after the war. It seemed that the gulf had been swept so carefully that the mine menace there had finally been eliminated. In the fall of 1958, however, mines began to pop up unexpectedly; they had broken loose from their moorings and were floating on the surface. Occassionally such mines were even caught in the nets of fishermen. Mines were even observed floating in the navigable channels as well. The vast water region had become dangerous to navigation.

It was essential on a crash basis to establish the reason for the sudden appearance of the mines and to correct the situation. One of the causes was found. After a careful inspection of the danger area it turned out that in 1943 in the Gulf of Narva three German ships, which were attempting to plant mines in the area, had been blown up by Soviet planted mines. A reserve of moored mines remained on the decks of the sunken vessels and around them. In time, the mooring lines had rusted through causing the bodies of the mines to break loose from their moorings and float to the surface. It was decided to destroy this underwater mine arsenal immediately.

Minesweepers passed over the sunken ships and dropped depth charges. An explosion of tremendous force followed and the mine menace was finally eliminated.

The explosion in the Gulf of Narva resounded like an echo of the war, a salute to those who courageously and fearlessly, at the risk of their lives, fought the mine danger throughout the war and continued to sweep the seas in the postwar period.

PART II
TORPEDOES
UNDERWATER ATTACK WEAPON /82

The modern torpedo is a weapon used by submarines, surface vessels, and mine and torpedo laying aircraft which make it possible quickly and accurately to launch a powerful underwater attack against enemy ships.

This is a self-propelled, self-controlled underwater projectile carrying an explosive charge in its forward portion. In contrast to mines the torpedo can be used to attack the enemy at a particular moment in time; and the target can be located beforehand from a great distance.

The modern torpedo is equipped with complex instruments which permit it automatically to control its own motion at a given depth and on a set course, and sometimes to follow a prescribed complex course.

Certain modern torpedoes have homing system which pick up a target and guide the torpedo to it. If the target attempts to dodge the torpedo the homing system will change the course of the torpedo; the torpedo then "overtakes" and strikes the target.

Use of influence type firing mechanisms insures that a torpedo will explode beneath a ship even if it does not impact directly against it.

Before the advent of torpedoes there was competition for a long time between artillery shells and armor as a result of which gun calibers increased rapidly and armor thickness was made correspondingly thicker. Subsequently, the development of technology permitted increasing the quality of armor which became the defense against artillery shells. In order to destroy the powerful, thick armor of enemy ships it was necessary to develop some new kind of weapon.

An underwater hole resulting from the explosion of a torpedo proved /83
much more dangerous than an above water surface hole from an artillery hit because the crew of the ship had to contend with the water which rapidly poured into the ship. The artillery shell did not have this same capability because on plunging into the water it quickly loses its speed and the flight direction imparted to it.

The weight of the explosive carried by a torpedo can be as much as 600 kg, and this is considerably greater than the amount carried in any artillery shell.

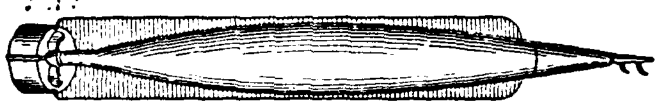

Fig. 36. The Whitehead torpedo

The torpedo, which became an organic weapon in the fleets of practically all nations in the 70's of the past century, has been subjected to continued improvement for a period of 90 years and has become one of the most effective means for the destruction of the largest warships and merchant vessels.

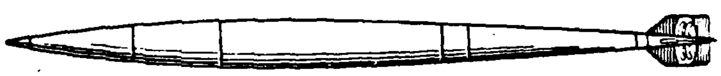

Fig. 37. Russian naval torpedo

The first self-propelled mine (torpedo) in the world was developed in Russia by the famous Russian inventor, I. F. Aleksandrovskiy, who in 1865 submitted a detailed plan for a torpedo to the naval ministry. One year later, Whitehead, an Englishman, announced that he had invented the torpedo. In spite of the good data obtained during tests of the Aleksandrovskiy torpedo, officials of the naval ministry preferred to buy the patent and torpedoes designed by Whitehead (fig. 36), which were no better in quality or characteristics than the Russian torpedo.

Torpedoes very quickly gained in popularity and became organic weapons in the fleets of most nations. Primacy in the successful tactical /84
application belongs to Russian seamen. In 1877-1878 during the Russo-Turkish War torpedoes launched from Russian torpedo boats sank a Turkish armed steamboat, the Intibakh. This was the first ship ever to have been sunk by the dread weapon -- the torpedo.

The emergence of the torpedo evoke radical changes not only in the construction and armament of the ships but also in the tactics of their employment. This called for the construction of new classes of ships.

Earlier built ships were re-equipped to make use of the torpedo and to protect ships against this weapon. The 1866 model of torpedo (fig. 36) resembled a spindle about 3.5 meters long with an overall weight of 140 kg (the explosive weighed about 8 kg); it had a speed of 6-7 knots and a range of 600-800 meters. It had vertical and horizontal controls. The vertical rudder was rigidly secured before firing and served to hold the torpedo along the desired course as it moved through the water. The horizontal rudder was connected to an automatic mechanism and controlled the depth of the torpedo.

The torpedo was activated by the propeller which was run by an engine powered by compressed air stored in a tank under pressure.

The first torpedoes were very unsophisticated; they were slow, had a limited range, and deviated from their preset course during the run. With such torpedoes it was difficult to hit even a vessel that was not in motion.

Russian inventors, engineers, and seamen contributed greatly toward perfecting the torpedo and, as a result, its design was greatly improved. In 1876 the Russian made torpedo (fig. 37) was six meters long, had a steel shell with a diameter of 38 cm, and weighed 25 kg. By 1900 the speed was raised to 20 knots by increasing the air reserve and the pressure of the air.

Lieutenant I. I. Nazarov, an officer of the Russian navy, proposed preheating the air entering the machine to increase engine economy in consequence of which it became possible to increase the air pressure and raise engine output. Use of the preheater equipment made for greater speed and extended the torpedo's range. /85

At the same time, the torpedo was equipped with more improved automatic instruments which increased the accuracy of motion with respect to both depth and direction.

Admiral S. O. Makarov, outstanding Russian scientist and naval leader, played a great role in the development of the torpedo and was the initiator of the science of torpedo tactics.

At the outset of World War I the torpedo became an organic weapon in the fleets of all warring nations. The success of this weapon can be judged by the amount of shipping sunk. Of 498 vessels sunk 154 had been the victims of torpedoes -- this included 14 battleships, 26 cruisers, and 36 destroyers. This fact revealed the exceptionally important feature of torpedoes in comparison with mines -- they could be selective in choosing the largest vessels for their victims. In addition, over 600 different surface ships with a total of 13 million registered gross tons and over 30 submarines had become victims of the torpedo.

After the first World War the torpedo became one of the basic weapons of war at sea. World War II again demonstrated how great a role could be played by the torpedo in naval warfare. Military encounters at sea rarely transpired without employment of the torpedo.

Out of a total of 429 large naval warships of the United States, Britain, and Japan lost, 159 were sunk by torpedoes fired from submarines aircraft, and surface ships, including three battleships, 20 aircraft carriers, 27 cruisers, and 108 destroyers. The torpedo was most effectively used by submarines and planes.

Collosal losses were inflicted through torpedo action against merchant shipping. For example, the submarines of Germany, Italy, and Japan sank a total of 14,550,000 gross registered tons of British, American, and other shipping; this represented over 60% of the total merchant fleet losses of all the capitalist nations.

The torpedo was subjected to continuous perfection and in a comparatively short time was converted into a formidable military weapon in the struggle at sea.

The scale of application of torpedoes in each successive war increased. Whereas in the 1877-1878 Russo-Turkish War only four torpedoes had been used, the total expended in the Russo-Japanese War in 1904-1905 rose to 263, and in the first World War the number shot up to 1,500 torpedoes. In World War II, however, the total launched by submarines, destroyers, and planes of the United States and England alone amounted to about 30,000 torpedoes.

By the end of the war more powerful explosive were being used in torpedoes and although the weight of the charge had not been increased /86 its explosive force was dramatically greater. Range and speed also were increased. The greater the speed of the torpedo was achieved in response to the fact that at comparatively slow speeds it consumed much time in its run toward the target during which the enemy could change course or take evasive action to avoid a torpedo attack.

Developing the means of detection which permitted spotting a target at great distances away called for increased torpedo range so that the submarine commander could fire at the target from concealment from a distance exceeding the range of operation of existing sonar detection gear. This was also of importance to torpedo planes because it moved back the point of drop of torpedoes at low altitude approaches and thereby decreased the time the aircraft was under enemy artillery fire during the attack.

In addition, increasing the speed and range of torpedoes facilitated attacks by torpedo boats, which, provided with radar equipment, could hit the enemy from great distances; this was very important since the advent of radar spotting equipment by the opposition made it difficult for boats to approach the target.

The combat characteristics of torpedo carriers, especially of submarines, were improved continuously. During World War II the Germans equipped their submarines with snorkels, devices which permitted submarines to travel under diesel power at periscope depth and, without surfacing, to charge their batteries.

A large amount of air is required for diesels to operate, and if there is no flow of air from the atmosphere they cannot be utilized. The snorkel made it possible to develop an air flow by means of a tube which could be raised above the water surface level while the boat itself remained under water.

The instant a torpedo was launched from the tube it created an unpleasant situation for the crew. An air bubble was formed on the sea surface when the torpedo was released. This was due to the compressed air /87
which forced itself to the surface after ejecting the torpedo from the tube, revealing to the enemy the position of the submarine at the moment of the attack.

To insure concealed torpedo fire a special device was used on the torpedo tube which insured fire without the formation of the bubble. Now the compressed air which forced the torpedo out of the tube remained inside the boat instead of rising to the surface.

But there was still another great shortcoming in the design of the torpedo itself. Torpedomen frequently complained that it was impossible to insure one of the most important factors of a successful torpedo launch -- concealment. Actually, while in motion under water the gas-steam torpedo leaves a visible trace behind it on the ocean surface (a mixture of water vapor and products of fuel combustion); it is made up of bubbles that rose to the surface without dissolving in the water to form a silvery green wake. The wake is the enemy of the torpedo crew because it enables the enemy to veer away from the torpedo's heading and thereby to thwart the attack; it also permits one to determine the position of the submarine rather precisely.

For a long time efforts to produce a wakeless torpedo were fruitless. The problem was not resolved until World War II. Instead of the gas-steam power plant used in German and American torpedoes an electric motor was adapted to perform this function; it was operated by battery furnished electric power. Nothing could now warn an enemy ship of the danger threatening it nor reveal the position of the submarine which had fired the

torpedo. To be sure, one had to pay a great price for this valuable feature; the speed and range of the torpedo run were greatly reduced due to the low energy reserve of the batteries. The electric motor was incapable of developing as much power as the gas-steam torpedo. The output of the gas-steam engine was 300-350 h.p. while that of the electric motor was 70-90 h.p. But even at this comparatively low speed of the electric torpedo (28-30 knots), the absence of a wake combined with the bubble-free discharge permitted the submarine greatly to increase the /88
success of the torpedo attack.

Some German designers strived to develop a wake-free torpedo and increased range by other means. The power plant was the same one used in the gas-steam torpedo, but instead of compressed air as the oxidizing agent, they used liquid oxygen, hydrogen peroxide, and the like. The spent products were dissolved in the water and left no trace on the surface.

Liquid oxidizers as a source of power are richer in oxygen than compressed air and their use made it possible to dispense with the heavy high pressure tanks. Use of liquid oxygen permitted reducing the weight of these torpedoes, a fact which permitted one to increase the weight of the charge and the quantity of fuel. However, these torpedoes had one drawback: the oxygen contained within them often exploded.

Wakeless oxygen torpedoes were first adopted as organic weapons in Japan. Following that they appeared in Germany. For an oxidizer the German torpedoes used hydrogen peroxide. Hydrogen peroxide breaks down with the addition of suitable catalyzers into steam and oxygen, giving off a considerable amount of heat in the process. Liquid fuel is injected into the heated mixture of vapors on the disintegration of peroxide, and there is a marked increase in the enthalpy of the gas mixture on combustion. In connection with the fact that ordinary seawater was used (rather than fresh water, which had to be contained in the shell of the torpedo) to cool the products of combustion and produce the working mixture in German-made experimental torpedoes, it was now possible to carry a considerable amount of fuel and oxygen. The use of oxygen in a torpedo increased the power plant output to 500 h.p., the speed to 45 knots, and the range up to 20 km. Simultaneously, improvements were being made in ways of protecting ships from the underwater weapon.

Strengthening the anti-mine side armor of a ship reduced the chances of destroying its vitally important centersthrough an explosion by contact with the side, the kind delivered by a torpedo equipped with a percussion firing mechanism. In addition, a well prepared torpedo attack oftentimes did not give the desired result: the torpedo passed underneath the ship's bottom or along either side without detonation since the torpedo did not directly strike the target. /89

The attempt to increase the destructive effect of torpedoes led to the development of influence firing mechanisms which increased the probability of a torpedo hitting its target in the least defended portion -- the ship's bottom.

The influence firing mechanism closed the detonator circuit and blew up the torpedo not as a result of a dynamic collision but in consequence of the action upon it of the physical field of the ship being attacked (magnetic, acoustic, and other fields). When a torpedo with an influence firing mechanism explodes underneath the ship's bottom a hole is formed whose dimensions ocassionally amount to several tens of square meters.

There are known cases wherein by means of one or several torpedoes equipped with influence type firing mechanisms were able to destroy tremendous sized ships with powerful side armor. In 1939, for example, the German U-27 submarine sank the Royal Oak, a 35,000 ton battleship with three torpedoes equipped with influence firing mechanisms. In order to destroy such a ship with torpedoes equipped with percussion type firing mechanisms no less than ten torpedoes would have been required.

Torpedoes are widely used not only on surface ships and submarines but torpedo planes, as well. Even in World War I there were recorded cases of torpedoes being used in planes. For example, in 1915 a British hydroplane torpedo carrier attacked a Turkish ship of 5,000 tons in the Sea of Marmora and sank it. But since such planes had a limited load capacity attacks by planes were not common.

During the period between the two world wars torpedo planes underwent an extensive period of development, and the weapon it carried, the aviation torpedo was widely used. The torpedo plane could now carry torpedoes (one or two) either underneath the fuselage, under the wings, or inside the fuselage. There were, in addition, torpedo planes in which the torpedo was "concealed" in the streamlined cowling in the lower portion of the aircraft fuselage. /90

The carrying of torpedoes by aircraft imparted great maneuverability to this weapon, a fact of great importance. Furthermore, it is much more difficult to evade torpedoes dropped by torpedo bombers very close to the ship than those launched by a destroyer. In order to reduce losses in planes and to accelerate a torpedo attack it was necessary to increase the speed and flight altitude of the plane when launching a torpedo. But this tended to increase the impact force of the torpedo against the water. It could break up and sink or sustain damage to its mechanisms and thereby fail to reach its target. Accordingly, the designers began to develop a device for the torpedo which would reduce the force of impact on entering the water.

To insure normal motion of the torpedo in the air and entry into the water they secured to the tail portion a stabilizer consisting of a metallic or wooden frame with vertical and horizontal fin assemblies (fig. 38). When the torpedo entered the water the stabilizing device was automatically disconnected from the torpedo.

During World War II parachutes were attached to torpedoes that were launched from a great height in order not to damage the torpedo shell. This method greatly reduced torpedo hit probability because while descending the missile oftentimes changed its heading. Accordingly, high altitude torpedo drops, as a rule, were restricted to torpedo bomber plane groups using special gyrating torpedoes. When such a missile entered the water the parachutes were automatically detached and the motors activated. The vertical rudders of gyrating torpedoes caused the weapon to describe spiral motions under water. These spiral paths were of very large radius. A torpedo successfully dropped on the ship's course usually hit the target.

A large number of warships and transports were sunk by torpedo bombers, a fact that tended to enhance the importance of torpedoes in the war at sea. New tactical applications were explored to improve the efficiency /91
of torpedo utilization, and its basic dimensions, weight, and other specifications were also improved.

Man-controlled torpedoes appeared almost simultaneously at the outset of World War II in the Italian, British, and German fleets. Great importance was ascribed to this new "secret" weapon. The main purpose of human-controlled torpedoes was to make surprise attacks upon enemy ships in his bases and places of mooring.

Because of their small dimensions these torpedoes succeeded in getting through the boom defenses and nets of ship bases and mooring areas and surreptitiously made their way to the enemy ship. The frogmen in the torpedo secured a powerful charge of explosive to the side of the ship (fig. 39) and quickly swam away to a safe distance. The charge exploded following a set time interval.

In December 1941 an Italian submarine approached the large, well protected British naval base of Gibraltar, fired torpedoes in each of which there were two men. They got through the booms and antitorpedo nets and slowly and unobtrusively approached the battleships Queen Elizabeth and Valiant, as well as a large transport. The frogmen disconnected the charges with timing mechanism from the torpedo, secured them to the bottoms of the enemy's ships and attempted to swim ashore but were captured.

Soon after, three mighty blasts resounded. The transport quickly sank and the two battleships of 32,000 tons each were seriously damaged and put out of action for a long time. In January 1943 the British paid a "return visit". They penetrated into the Italian base of Palermo and sank the cruiser Ulpio Traiano and a transport.

Just how were these "live" torpedoes constructed? One or two men sitting inside controlled these torpedoes. They wore wet suits and were equipped with oxygen breathing gear. Like a modern submarine the "live" torpedo could travel either at periscope depth (the heads of the divers were above water) or it could move underwater. The "live" torpedo had approximately the same outline and dimensions as an ordinary torpedo. /93
For a power plant it carried an electric motor powered by a storage battery. They attached a charge to the nose of the torpedo which could be disconnected. The man sitting in the torpedo was shielded against the pressure of the water by a steel plate erected in front of the seat.

These torpedoes had a speed of only several knots. Such'live" torpedoes were delivered to the enemy port either by a surface ship or by a submarine.

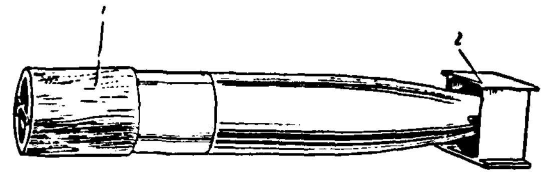

Fig. 38. Stabilizing device of an aircraft launched torpedo
1. Anti-concussion device; 2. stabilizer.

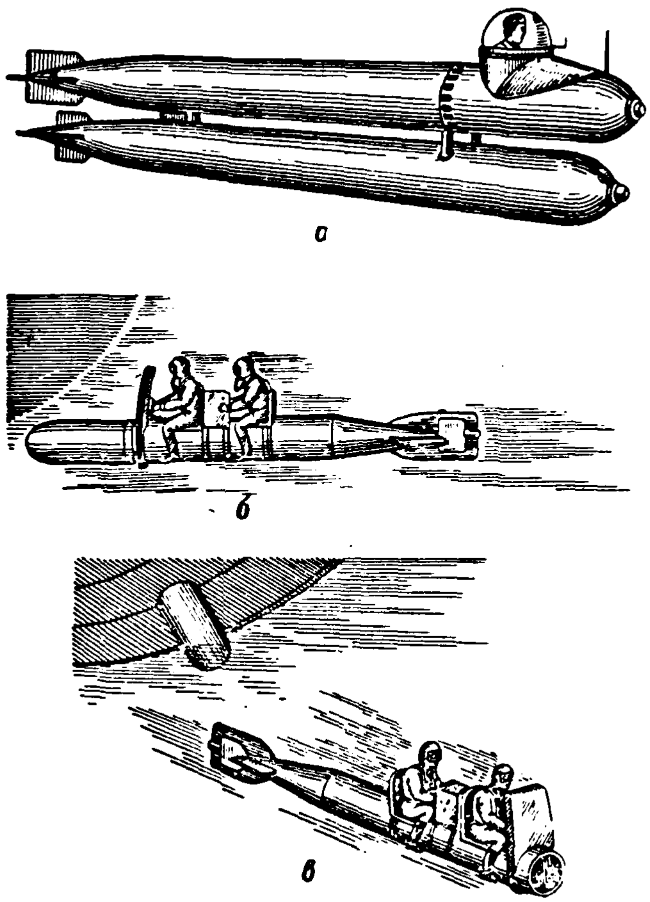

Fig. 39. Human controlled torpedoes

a. Controlled, double bodied torpedo; b. "saddle" type single body torpedo and its two controlmen; c. after securing a charge to the bottom of the enemy ship the drivers activate the timing mechanism and quickly depart from the site where an explosion will soon occur. /92

The English "live" torpedo controlled by two frogmen had a caliber of 53 cm, a length of about eight meters, and the weight of the explosive charge was about 220 kg.

The German "live" torpedo was controlled by one man who released a self-guiding armed torpedo against an enemy ship from a short distance. In contrast to the Britishtorpedo the German version actually consisted of two torpedoes: the upper or carrier of the individual, and the lower or the actual torpedo.

"Live" torpedoes had some rather substantial drawbacks: while in motion the torpedo drivers were exposed above the water surface and therefore readily visible under conditions of good visibility. In addition, the driver had no instruments, and when submerged in the water could see nothing.

During the Normandy operation in the invasion of Europe the Germans tried to attack such torpedoes with their own guided torpedoes. The escort ships protecting the convoy readily detected these torpedoes by thir transparent inspection cap extending out of the water and blinded them with searchlights, following which they were rammed and destroyed with artillery fire.

In November 1944 a unit was formed in Japan to man "human torpedoes" which were submarine borne. In order for the torpedo to hit the target accurately the man was not ejected from his seat but was blown up together with the torpedo.

It is impossible, of course, to negate the recognized effectiveness of human controlled torpedoes. However, the experiences with this kind of weapon in wartime demonstrated that a well organized system of observation and the employment of modern spotting equipment serve as a good guarantee against surprise attacks by such "human torpedoes" on which the supporters of the secret war at sea counted so heavily. /94

The great success of torpedoes in the war at sea was also explained by the rapid development of torpedo fire control instruments. Sonar gear enabled a submarine to approach an enemy ship stealthily without surfacing or lifting the periscope at salvo range, determine its course and speed, and then with the aid of fire control instruments resolve the torpedo-ship collison course problem. But the slightest error in computation or mistakes in determining the course and speed of target reduced the chances of a successful attack and the torpedo would miss its target.

The designers strived to produce a torpedo which would automatically correct any errors introeduced by the torpedomen in solving the torpedo-target collision course problem and would alter its course in attempts by the target vessel to take evasive action. A torpedo of this type was finally developed.

Electrical T-V type homing torpedoes made their appearance in Germany toward the end of World War II. Equipment in these torpedoes trapped sounds given off by the ship's propellers as well as by the vibrating portions of its hull. On "hearing" the noise of the ship the homing torpedo would head toward the source of the noise and then overtake and destroy it.

Acoustic homing gear insured the successful action of the torpedo even though the ship-target had detected the moment of launch and proceeded to take evasive action. The homing torpedo greatly increased the probability of a torpedo hitting its target. Conditions arose whereby it became difficult for a vessel to take evasive action against one torpedo, to say nothing of a salvo of torpedoes.

By the end of World War II the gyrating torpedo came into being (fig. 40). Installed in this torpedo was a device in which the course of the torpedo -- zigzag or spirals -- was programmed beforehand. If, after traveling a prescribed distance the gyrating torpedo failed to encounter the target at the computed point the maneuvering device caused it to describe a curvilinear trajectory of a prescribed form or to move in a spiral course. This made for greater hit probability, especially against ships traveling in large units or convoys.

During the postwar period, as before it, much attention is directed to the matter of increasing the speed and range of torpedoes. We know that modern torpedoes are greatly superior to the models used during the war in this respect.

Scientists and engineers striving to produce fast moving torpedoes are developing power system based on new principles. Work is underway on the construction of high speed jet torpedoes.

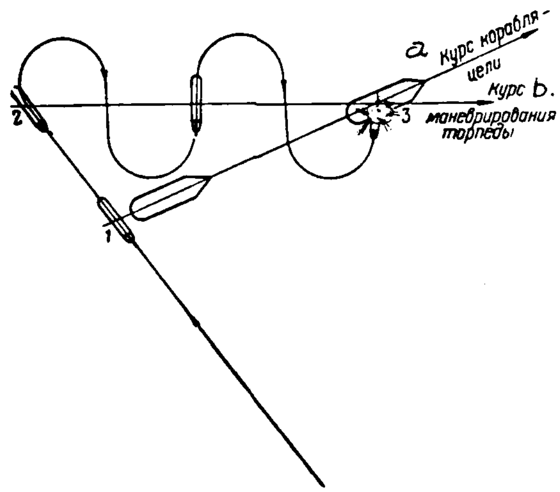

Fig. 40. Firing a gyrating torpedo:
1. Torpedo has missed target; 2. gyrating switch cut in; 3. torpedo has overtaken target; a. course of target ship; b. course of gyrating torpedo.

The Italian magazine Rivista M-rittima announced that a variety of jet engines have been developed for use in torpedoes. The movement of a torpedo in this situation is produced by the jet stream exiting from the combustion chamber located in the tail section of the torpedo.

The rate of speed developed by jet powered torpedoes during the 1944-1946 period was 70 knots. According to foreign specialists jet engines enable torpedoes to develop still greater speeds and therefore they hodl great promise.

In the Italian PX-5 jet engines, for example, combinations of alkaline metals and seawater are used to produce higher thermal energy. In this /96 case the products of the compound containing steam and hydrogen are ejected at great velocity through the nozzle into the water thereby creating a reactive thrust for the torpedo's motion.

Fig. 41 shows the construction of an underwater torpedo projectile with jet engine. The speed of this underwater weapon is considerably greater than that of modern torpedoes since it has a more powerful engine and a shape based on a new principle; it resembles a missile for motion through air.

The torpedo has the following characteristics: length - 7.5 meters, diameter - 515 mm; overall weight - 1,000 kg; weight of explosive - 300 kg; weight of fuel (borane)* - 180 kg, and time of underwater run - 36 seconds.

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* Borane is a chemical compound of boron and hydrogen with a lower specific weight than aviation fuel but yields 1.5 times more heat on combustion.

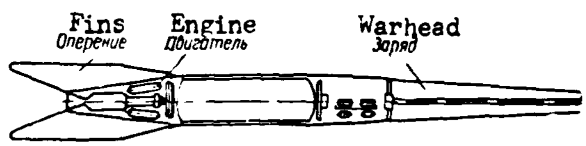

Fig. 41. Italian jet type underwater missile torpedo U-6.

The advantage of jet engines operating on high energy fuels consists also in their simplicity of design and low production costs.

THE TORPEDO IN BATTLE

In naval battles the torpedo is a formidable weapon. Our boatmen, submariners, and fliers have made effective use of the torpedo in battles at sea with the German invaders. With their accurate, well-planned torpedo attacks in close cooperation with the artillery they sent to the bottom hundreds of enemy ships and transports. The Soviet navy during World War II sank 676 enemy transports for a total of 1,586,553 tons and 614 naval ships and auxiliary craft. Most of these were sunk by torpedoes. /97

The torpedo is a universal weapon. It can be fired from ships of various classes -- from the smallest torpedo boats to large ships. The torpedo is the basic weapon for submarines, torpedo boats, and torpedo bomber aircraft.

At the outbreak of World War II even battleships were armed with torpedoes. For example, the German battleships Tirpitz and the Gneisenau carried six torpedo tubes and the Graf Spee had eight tubes. Four British battleships of the Royal Sovereign class were also equipped with torpedo tubes. However, these ships never went into torpedo attacks and never fired torpedoes. The cruisers of practically all countries all carried torpedo tubes. The Prinz Eugen, for example, had 12 torpedo tubes. The are recorded cases of heavy cruisers having launched torpedoes and sunk enemy ships. However, torpedo attacks by large surface ships were only random occurrences, and in most foreign fleets today torpedoes have been removed from cruisers.

The most numerous class of surface ships with strong torpedo and artillery armament during the past war were the destroyers. In that war destroyers were common to all navies and participated in naval battles in all the theatres of war. For example, at the beginning of the war the British fleet numbered about 200 destroyers, the Italian over 100, the American fleet over 200, and the Japanese135.

xamples of torpedo attacks by destroyers are numerous. We will cite certain of these. In March 1942 a detachment of Italian ships in formation with the battleship Littorio, two heavy cruisers, and destroyers attempted to attack a British convoy in the Malta area. British destroyers supported by cruisers launched a torpedo attack, firing a salvo from a range of about 30 cable. One torpedo struck the Italian battleship, creating serious damage and the Italians were forced to give up their pursuit of the British convoy.

The German battleship Bismarch of 43,000 tons displacement was sailing the Atlantic Ocean during the month of May 1941. On the night of 26-27 May five British destroyers spotted it and fired several torpedo salvos in an attempt to halt its movement into the operational area of their own main battle forces.

Sailing at high speed the Bismarck attempted to escape pursuit, but failed to do so. In consequence of repeated torpedo attacks by destroyers and torpedo bombers several torpedoes hit the battleship,forcing it to reduce speed drastically. On the following norning the main forces came up and proceeded to sink the Bismarck. A total of 3,000 artillery shell and over 70 torpedoes were fired at the Bismarck, eight of which struck home and thus decided the issue.

During the Great Patriotic War Soviet sailors executed many successful attacks against the enemy with destroyer launched torpedoes. For example, at the beginning of the war on the Black Sea the destroyers Boykiy and Besposhchadnyy were ordered to intercept a German convoy. Taking advantage of a thick fog, our ships aprroched the enemy at close range and carried out a torpedo attack. As a result of several torpedo and artillery hits two transports, a tanker, and a patrol boat were sunk. Despite the fire from enemy ships and coastal batteries the destroyers routed the enemy convoy and successfully completed their assigned mission. Thus, a sudden, daring torpedo and artillery attack by Soviet destroyers insured the success of the task.

In the Baltic our destroyers also routed large German convoys. In July 1941 a total of 28 enemy ships were destroyed and 14 damaged as a result of two attacks. The destroyers Steregushchiy, Surovyy and Artem fired torpedo and artillery volleys, destroying a large enemy convoy.

The destroyers Serdityy and Sil'nyy went into action against a German cruiser and two destroyers which were attempting to break through into the Gulf of Riga. By virtue of their artillery fire and torpedoes the Soviet destroyers sank one enemy destroyer and inflicted serious damage upon two other ships. The enemy attempt to break through into the Gulf of Riga was thwarted. /99

As a rule, torpedo attacks were delivered at night in cooperation with artillery support. In the Battle of Cape Matapan in March 1941 Italian destroyers carried out several torpedo attacks with the object of separating their own main forces from the overwhelming superiority of British vessels. The British ships were forced to change course thereby permitting the Italian ships, which had sustained damage in the action, to withdraw from the pursuit. At night the British destroyers spotted these ships, approached them at close range, and fired a torpedo salvo, sinking the Italian cruisers Zara, Pola, and Fiume.

There are numerous examples of large ships sunk by destroyer launched night torpedo attacks, such as the American heavy cruiser Northampton, the British light cruiser Charybdis, the American light cruiser Helena, and others.

Daylight attacks were usually undertaken with the object of forcing enemy vessels to change course and thereby offer their own ships an opportunity to assume a more favorable position, or give up the pursuit and under favorable circumstances even to launch a torpedo attack. In October 1944 a torpedo attack by American destroyers in the Battle of Samar Island (Philippine Islands) against Japanese battleships held up enemy forces and reduced the intensity of his artillery fire; this enabled them to save the American aircraft carriers which were in great danger.

However, in most cases daytime torpedo attacks were not very effective. In February 1942 during a daytime attack in the Java Sea out of 177 torpedoes launched by Japanese destroyers against American ships only one hit its target. During the Battle of Komandorskiy Islands out of 70-80 torpedoes released not one scored a hit. The difficulty of approaching /100 an enemy ship at close range and the possibility of enemy ships taking evasive action due to the visible wake were the reasons for these failures.

According to "Jane's Fighting Ships" modern destroyers are equipped with long range homing torpedoes, launchers, boosters for launching rockets, etc. The torpedo boat is a small craft armed with several torpedoes. It has great maneuverability and speed, is able to break through enemy naval artillery fire barrages and successfully sink them with torpedoes.

Improving the seaworthiness and speed of torpedo boats and the use of radar equipment permitted their broader use during World War II for attacks upon ships and transports not only at their bases but at sea as well.

More than 1,500 torpedo boats were in service during the war. Several thousand day and night torpedo attacks involving the sinking of hudreds of of ships and transports were the result of their activities.

The modern torpedo boat has as many as four torpedo tubes. The boat dimensions are not too imposing: they are from 18 to 20 meters long but have a power output of 2,000 horse power or more and therefore capable of developing speeds up to 50 knots, or twice as great as the speed of large surface vessels (fig. 42). Because of their high maneuverability and speed torpedo boats are not highly vulnerable. It is difficult for the vessel under attack to take successful evasive action against torpedoes fired at close range.

In the past war torpedo boats have successfully attacked even well armed cruisers and destroyers. Soviet torpedo boat sailors won many brilliant victories and performed superhuman feats of bravery and skill in the Great Patriotic War.

In July 1941 four torpedo boats in the Baltic Sea under the command of V. P. Gumanenko attacked an enemy convoy consisting of 13 tansports and 35 warships that were protecting them. After setting up a smoke screen the boats broke up the formation despite the hail of enemy fire; they fired torpedo salvos at close range and sank a destroyer and two transports bearing troops and artillery equipment. Maneuvering skillfully and taking advantage of the cover offered by the smoke screen the boats returned without loss to their base.

In September 1941 a group of torpedo boats in the Baltic Sea carried out a surprise attack on a detachment of German ships, destroying two destroyers and a cruiser. This is how it happened.

On 23 September 1941 a large detachment of German ships consisting of a cruiser and five destroyers entered Liyu Bay on the Island of Sarema and opened heavy artillery fire upon our coastal defenses. The enemy was convinced that he faced no danger from the sea because our large warships were some distance away and the smaller ships, he thought, would not run the risk of attacking such a strong enemy force. Suddenly, a quite by surprise, four small dots appeared in the haze, approaching at full speed.

The Germans poured a withering fire upon the boats, which did not change course but proceeded ahead to sink a cruiser and two destroyers with torpedoes. Without giving the enemy an opportunity to recover from this attack the boats reversed course and withdrew from firing range, returning satisfactorily to base. These boats were commanded by Afanas'yev, Ushchev, Kremenskiy, and Naletov.

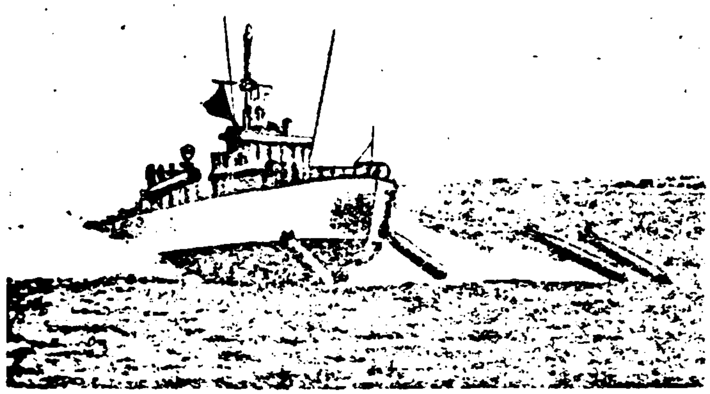

Fig. 42. English torpedo boat launching a four torpedo volley.

In driving the Germans out of the Crimea the enemy suffered exceptionally heavy losses from attacks by our planes, submarines, and torpedo boats. Fleet Admiral I. S. Isakov wrote: "But the Black Sea torpedomen had /102
an exceptionally good holiday. During the entire war despite their intensive military activities they had no such opportunities as in this operation, and they took full advantage of them."*

* I.S.Isakov, The Soviet Navy in the Patriotic War, Military Publishing House, 1945.

According to by no means complete data torpedo boats of foreign nations sank two cruisers, 20 destroyers, about 60 piecket ships and sweepers, several submarines, and a large number of freighters between 1939 and the end of the war.

World War II confirmed the supreme importance of submarines in the war at sea. The total dominance of the surface fleet -- battleships and cruisers -- was forever lost. Armed with that powerful weapon, the torpedo, submarines were capable of approaching stealthily and effectively striking them (fig. 43).

In 1939 the warring powers had about 500 submarines and by the end of 1942 Germany alone had over 380 of them (throughout the duration of the war Germany had built 950 submarines).

Submarines operated under the most varied conditions. For example, in October 1939 a German submarine penetrated under concealment into the British naval base at Scapa Flow and sank the battleship Royal Oak. In November 1944 the British aircraft carrier Ark Royal was sunk at Gibraltar, and in that same month the British battleship Barkham was sunk off the African coast. British midget submarines penetrated into Altenfjord in September 1943 and torpedoed the German battleship Tirpitz, putting it out of operation for a long time.

Between 1939 and 1945 German, Italian, and Japanese submarines sank 2770 allied and neutral freighters with a total of 14,550,000 gross tons. During the war in the Pacific the United States submarines sank over 1,000 Japanese merchant ships, expending 15,000 torpedoes. The Americans used an average of 13 torpedoes for each ship sunk.

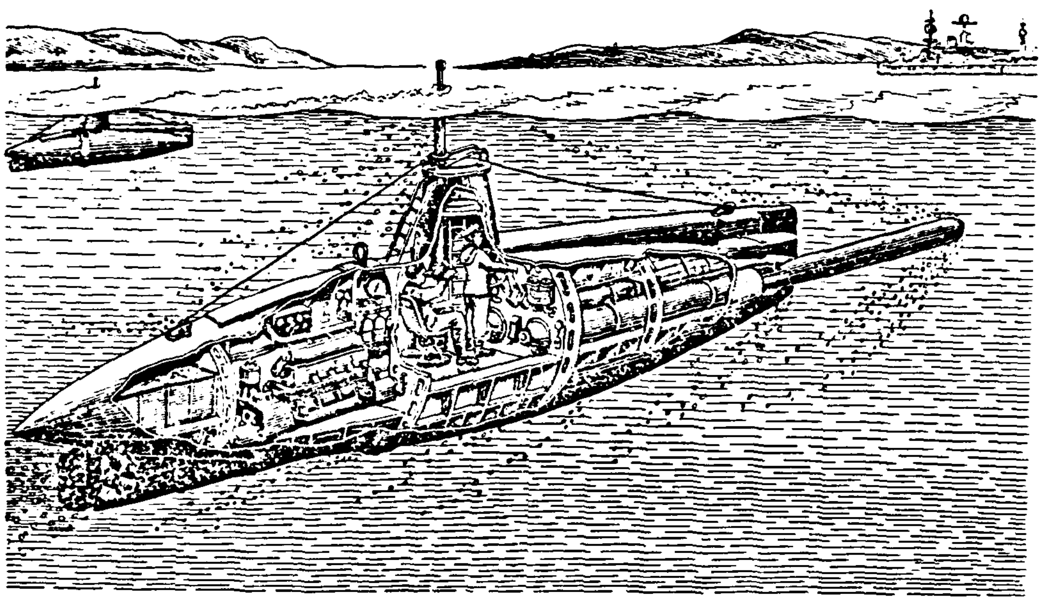

Fig. 43. Midget Japanese submarine attacking enemy ships.

Attacking enemy warships and transports German submarines often used nigh tactics for simultaneous surface attacks from several directions /103
(so-called wolf packs), firing a large number of torpedoes.

Our submarines in the North, Baltic, and Black Seas represented a powerful naval striking force which operated successfully against enemy shipping lines.

Soviet submariners frequently broke through the formidable screens of enemy ships and successfully attacked his warships and transports by skillful, bold maneuver. On one voyage a submarine commanded by Hero of the Soviet Union I. I. Fisanovich sank a large German transport. Enemy ships unleashed a violent attack upon the submarine. Seams were loosened from near bursts and water began to flow into the submarine. An oil slick began to collect on the surface revealing the position of the boat. Many of the mechanisms were knocked out and the gyrocompass failed to respond. The situation became extremely critical. The commander did not lose his composure, and the crew responded to his orders with precision. Getting their bearings by soundings of the sea, Fisanovich failed his craft to the protective cover of friendly coastal batteries.

In breaking through the protective screen and sinking enemy transports, submarines oftentimes were surrounded by enemy ships. Saving the crew and the submarine depended on the endurance of the men, the training of the asdic operators, and on the swift and efficient actions of the men. Soviet seamen, possessed of iron endurance and knowing their weapons and mechanisms to perfection, emerged as victors in mortal struggles with the enemy.

The submarine K-22 commanded by that daring commander, V. N. Kotel'nikov spotted an enemy transport along the coast while sailing in enemy waters. It was very difficult to approach the transport due to the presence of shoals and reefs. Maneuvering with great skill he attacked the transport with torpedoes. A German escort ship appeared suddenly. It was impossible to evade it in the underwater position and the commander made a daring decision to surface and beat off the attack with artillery fire. Everyting now depended on the speedy teamwork of the crew. In literally a few minutes after surfacing the boat opened fire. In the second volley the escort vessel was destroyed. After finishing off the sinking /105
transport with artillery fire the boat spotted yet another transport which it proceeded to sink with several artillery rounds. Having sunk two transports and an excort vessel the boat returned victoriously to its base.

Baltic submariners had to operate under especially difficult conditions. Throughout the war the enemy laid about 50,000 mines -- both contact and influence types -- in the Finnish Gulf alone. But the Baltic submariners penetrated the minefields and struck heavy blows against the enemy.

In commenting on the fearlessness and heroism of the Baltic seamen a Swedish newspaper, for example, stated that Soviet submarines, commanded by bold, desperate officers are unquestionably breaking through narrow, well mined, and extremely well defended waters of the Gulf of Finland and will not allow the Germans to establish dependable lines of communication.

Submarines are undergoing improvements continuously at the present time. They have greater maneuverability and speed and are equipped with the latest gear.

According to the foreign press Americans, British, and the French are installing atomic power plants in their submarines in place of the conventional power plants. Use of atomic power allows submarines to sail at high underwater speeds and cover great distances without replenishment of the fuel supply.

It was reported that the submarine Nautilus has an underwater cruising range of about 40,000 milés at 20 knots, expending 80 grams of atomic fuel per day. It is equipped with six bow torpedo tubes, has a dive capability of 200 meters, and a total displacement of over 3,000 tons.

Torpedo bomber planes were widely used during World War II. The great range, speed, maneuverability, and accuracy of torpedo launchings are the valuable tactical features of a torpedo bomber that are necessary for a successful torpedo attack (fig. 44). Actually, it is very difficult for a ship to take evasive action against a torpedo launched by this type of plane. /106

During the past war the fleets of the United States, England, and Japan lost over one-third of the total tonnage sunk due to enemy naval aircraft operations.

Torpedo bombers attacking well armed enemy ships often used the tactic of simultaneous attack from several directions and this tended to scatter enemy artillery fire, increase the efficiency of torpedo attack and reduce aircraft losses.

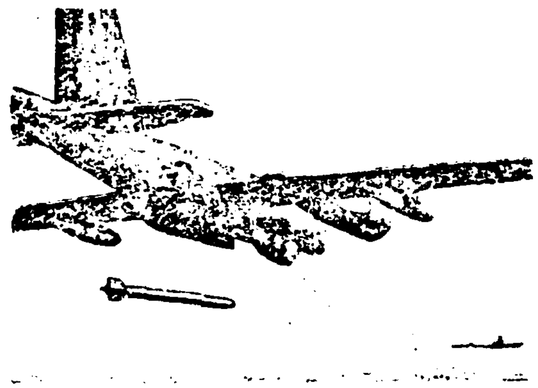

Fig. 44. American torpedo bomber attacking an enemy submarine

On the night of 12 November 1940 carrier launched British torpedo planes of the Mediterranean fleet attacked Italian ships in the harbor of Taranto. Approaching the enemy ships at great altitude the planes dived in and dropped 11 torpedoes from medium altitude. Nine of the torpedoes hit their targets, resulting in damage to three Italian battleships and two cruisers. Thus, in a single attack the Italian fleet lost about half of its capital warships.

In December 1941 about 300 Japanese planes took off vrom their carriers, attacked American ships tied up in Pearl Harbor, their main base in the

Pacific. The attack was a complete surprise to the Americans. As a result of this attack by torpedo planes and bomber aircraft, four battleships, a cruiser, and three destroyers were sunk. In addition, four battleships, three cruisers, and several other vessels were heavily damaged. /107

Oftentimes torpedo bombers attacked enemy ships at sea or struck vessels attempting to escape pursuing ships. In December 1941 the battleship Prince of Wales and the battle cruiser Repulse left the British naval base at Singapore and stood out to sea. They were spotted by Japanese torpedo bomber planes which immediately launched an attack. The ships set up a heavy artillery barrage. However, the torpedo planes pressed the attack despite the withering fire and successfully released several torpedoes. Soon after, the two giants of the disappeared beneath the waves.

Our own naval air forces played an outstanding role in the military operations at sea. They destroyed enemy warships and other vessels at sea, and bombed his ports and bases. As a result of torpedo bomber attacks about 400 enemy transports with a total displacement of 800,000 tons and over 400 warships were sunk.

Our fliers broke through to enemy bases and destroyed shipping, attacked convoys, and sent many transports to the bottom. The enemy was given no peace, day or night.

In May 1944 an enemy convoy consisting of seven transports, four destroyers, minesweepers, and other auxiliary ships was spotted along the northern coast of Norway. Our torpedo bombers intercepted the convoy and in a few hours sank seven enemy ships and damaged five. In addition, 12 enemy planes were shot down.

The exploits of Hero of the Soviet Union Captain V. N. Kiselev are covered with everlasting glory. On one ocassion he took off to attack an enemy convoy defended by warships and fighter planes. He selected a large transport and begin his torpedo run. His plane was hit by a hail of enemy antiaircraft fire. Flames enveloped his plane. Despite all this Kiselev set his plane on an accurate bombing run and dropped his torpedo which found its mark and sent a German transport to the bottom. This was the fourth victory for this courageous crew.

The imperialist governments, chiefly the United States, attribute great importance in their aggressive plans to the development of many planes and are constructing numerous aircraft carriers. In 1958, for example, the U. S. Navy counted some 100 aircraft carriers. The very largest /108 of these was the attack carrier Forrestal with a total displacement of 75,000 tons and a flight deck over 300 meters long. It is capable of accomodating over 100 planes armed with bombs or torpedoes.

CONSTRUCTION OF THE TORPEDO

The modern torpedo is an underwater projectile containing complicated instruments and a powerful charge of explosive designed to destroy a ship at its most vulnerable place, the underwater section.

Most modern torpedoes consist of our parts connected together (fig. 45): the warhead; compressed air bottle or storage battery; the afterbody with power plant and control instruments;and the tail section with rudders and propeller.

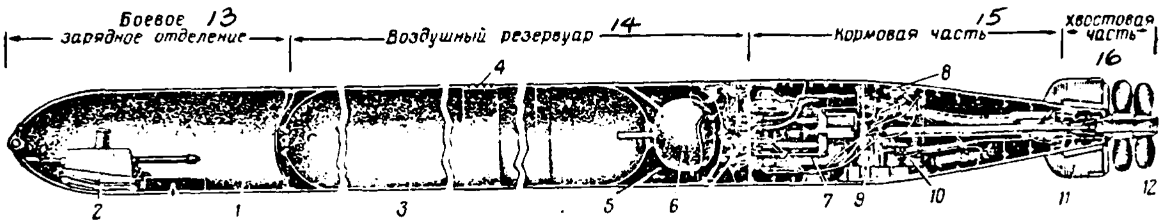

Fig. 45. Gas-steam Mk-15 American torpedo (cross section view)

Key: 1. Explosive charge; 2. firing mechanism; 3. air bottle; 4. guide stud; 5. water compartment; 6. fuel tank; 7. main power plant (turbine); 8. starting device (trigger); 9. hydrostatic instrument; 10. gyroscope; 11. vertical rudder; 12. propellers; 13. warhead; 14. air bottle; 15. afterbody; 16. tail section.

We distinguish between several types of torpedoes, depending on the power plants (steam-gas), electrical, or jet) and the method of detonation (contact, influence). However, the principle of design of most instruments in these torpedoes is the same. Let us consider in detail the steam-gas torpedo. /109

During World War II all foreign fleets used steam-gas torpedoes, for the most part, such as the Mk-14 and Mk-15 in the United States, the 21 and Mk-8 in England, etc) in which a steam-gas mixture served as the "fuel" for operating the power plant.

The warhead of the steam-gas torpedo is located in the nose of the torpedo and houses the explsovie charge and firing mechanisms. TNT, Torpex, and other substances are used as explosives, just as in mines. In order to increase the density and, therefore the weight of the explosive it is poured into the torpedo warhead in molten condition.

Inasmuch as TNT has low sensitivity to mechanical shock, highly sensitive explosives -- primary and secondary detonators -- are used in the torpedo to explode the main charge.

Highly sensitive explosives, such as mercury fulminate, lead azide, and others,which detonate from a slight shock,can be used as primary detonators. To reduce the danger of explosion on shipboard a small quantity of explosive, insufficient to explode the main charge, is placed in the detonator. The primary detonator is placed in the detonator intrusion tube, the secondary detonator which contains an explosive less sensitive to shock, such as 600-800 grams of tetryl, which is fully adequate to detonate the main charge of the torpedo.

The primary detonator is exploded by contact or influence firing mechanisms. Among the contact firing mechanisms are the impact whisker pistol and inertia pistol (fig. 46). The impact whisker pistol is inserted horizontally into the forward part of the torpedo warhead. When the torpedo impacts against the side of a ship the spring activated impact whisker heats the percussion cap of the primary detonating charge which ignites the secondary detonating charge, thereby exploding the main charge.

In order to bring about an explosion when a torpedo hits a ship even at an angle, the impact whisker pistol is provided with several metallic levers or whiskers spreading in different directions. When one of the levers grazes the side of the ship the lever is moved and disengages the pistol which heats the detonator and causes the explosion. /110

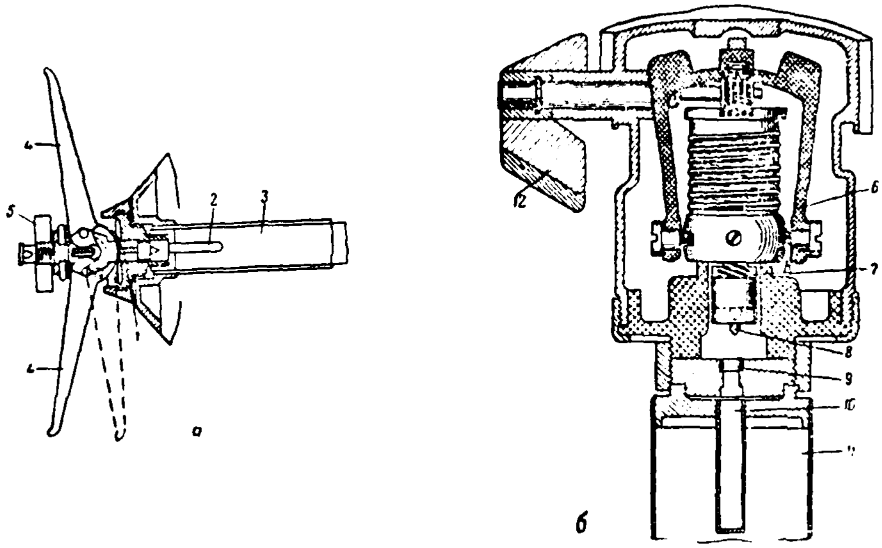

Fig. 46. The Mk-15 torpedo contact firing mechanisms
Key: 1. Impact whisker pistol; b. inertia pistol; 1. firing pin; 2. primary detonating charge; 3. secondary detonator; 4. whiskers; 5. safety vane; 6. pendulum; 7. main spring; 8. firing pin with needles; 9. percussion cap; 10. primary detonator; 11. secondary detonator; 12. safety vane.

To protect the torpedo against premature explosion in the vicinity of the firing ship the firing pin rod of the impact whisker pistol is locked by the safety vane. After the torpedo is fired the vane begins to rotate under the influence of the oncoming stream of water encountered and completely releases the firing pin when the torpedo has traveled the danger distance.

The inertia pistol is inserted into a special opening of the warhead. The main part of the inertia pistol is the vane which is held in a vertical position at all times, thereby locking the firing pin. When the torpedo impacts against some object the vane is shifted in the direction of the impact and liberates the firing pin which heats the disruptive detonator and the torpedo explodes.

To prevent an explosion on the firing ship from random vibration, impact, or shock of torpedo against water at the moment of firing /111 there is a safety device in the inertiapistol which locks the pendulum.

The safety device is connected with the vane shaft. As the torpedo moves the vane rotates and gradually releases the pendulum, lowering the needle and compressing the main spring of the firing pin. The pistol is placed into firing positi n after traveling 100 to 200 meters. There are many different types of torpedo contact firing mechanisms. American made torpedoes, for example, use the Mk-6 inertia firing mechanism shown in fig. 47. The explosion of a torpedo with a firing mechanism of this kind occurs as a result of closing an electric circuit and not because of the firing pin striking against the percussion cap.

The safety device which protects against accidental explosion also consists of a vane. The shaft of the vane rotates the shaft of a direct current generator which develops energy and charges the condenser which acts as a storage battery of electrical energy.

At the beginning of the motion the torpedo is safe -- the circuit from the generator to the condenser is opened with the aid of a moderator wheel and the detonator is inside the safety chamber. When the torpedo has traversed a certain distance the rotating shaft of the vane raises the detonator from the chamber, the moderator wheel closes the circuit, and the generator begins to charge the condenser.

When the torpedo collides with the target the ball in the inertia firing mechanism moves forward due to inertia and the spring contact is closed with the fixed contact. When the circuit is closed the condenser opens; the discharge current ignites the disruptive detonator which causes the total charge to explode. Impact and inertia whisker pistols explode the torpedo only on contact against the side of a ship. In order to increase torpedo hit probability and strike the ship's bottom most modern torpedoes have influence firing mechanisms.

The operating principles of torpedo influence firing mechanisms in foreign torpedoes are quite varied and are based on the use of physical fields produced by the ship. They include magnetic, acoustic, hydrodynamic, and optical firing mechanisms. /113

The action of an optical type influence firing mechanism, for example, is based on the external photoelectrical effect. A photoelectric cell is used here as a receiver device which is sensitive to changes in illumination in water when a torpedo passes through the shaded zone beneath the bottom of a ship (fig. 48a).

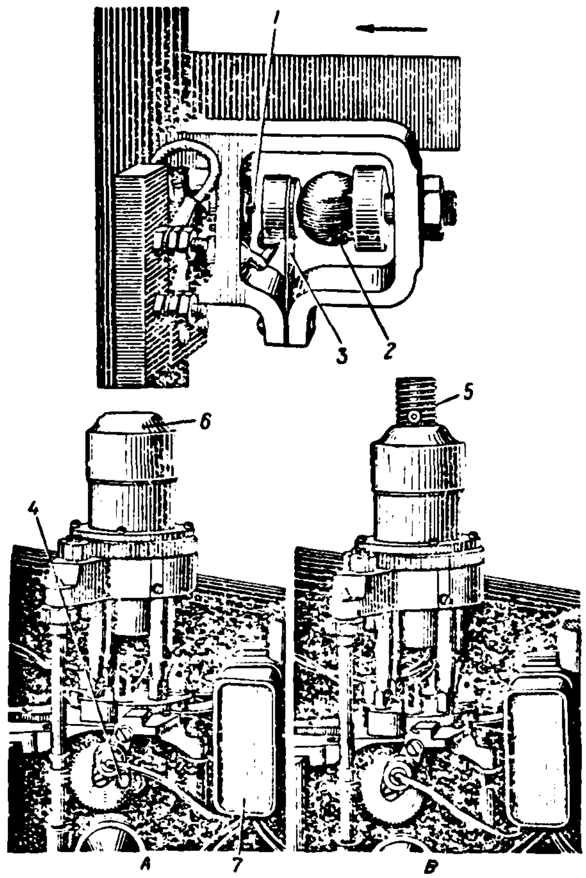

Fig. 47. The Mk-6 American torpedo inertia firing mechanism with ball:
Key: A. Firing mechanism in safety position (detonator in safety chamber); B. Firing mechanism in armed position (the detonator has emerged from the safety chamber); 1. fixed contact; 2. small ball; 3. spring contact; 4. moderator wheel; 5. detonator; 6. safety chamber; 7. condenser.

A device producing its own physical field, e.g. a device which radiates audio or ultrasonic waves, can be used as a torpedo influence firing mechanism. While the torpedo is in motion sound waves are radiated upward and are reflecged from the sea surface at a certain angle. When the torpedo passes beneath the ship the sound waves are then reflected off its bottom whereupon the angle of the reflected waves and the time will be different; this will be perceived by the influence firing mechanism and the torpedo will explode (fig. 48b).

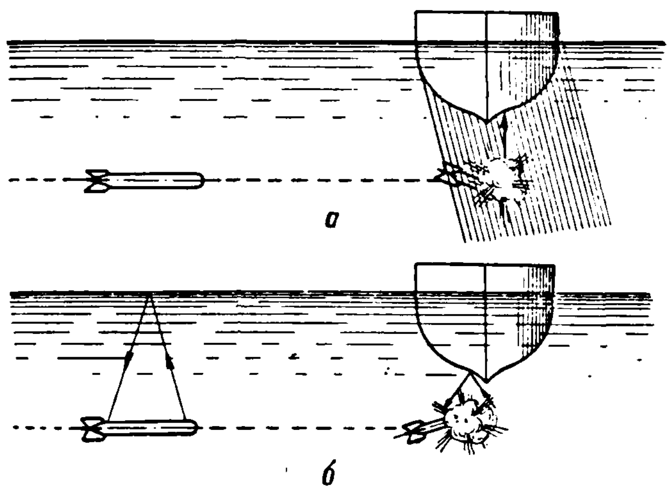

Fig. 48. Influence firing mechanisms used in torpedoes

a. A photoelectric cell is installed inside an influence firing mechanism which, on entering a shaded area under the ship, triggers the firing mechanism and the torpedo explodes. b. An acoustic influence firing mechanism radiates uninterruptedly and receives sound waves reflected from the water surface; on reflection of sound waves from the bottom of the ship the time and angle of reflected waves change, and firing mechanism is triggered causing an explosion to take place.

During World War II the British used in induction type influence firing mechanism. The influence firing mechanism was triggered both by influence and by contact action of the ship on the torpedo. In the influence firing mechanism there is an induction coil with a core which "senses" changes /114 in the ship's magnetic field. It is series connected with two positive ("+relay") and negative ("- relay") magnetic-electric relays. The induction coil is installed in the warhead along its longitudinal axis and, consequently, it reacts to the projection of the horizontal component of the ship's magnetic field.

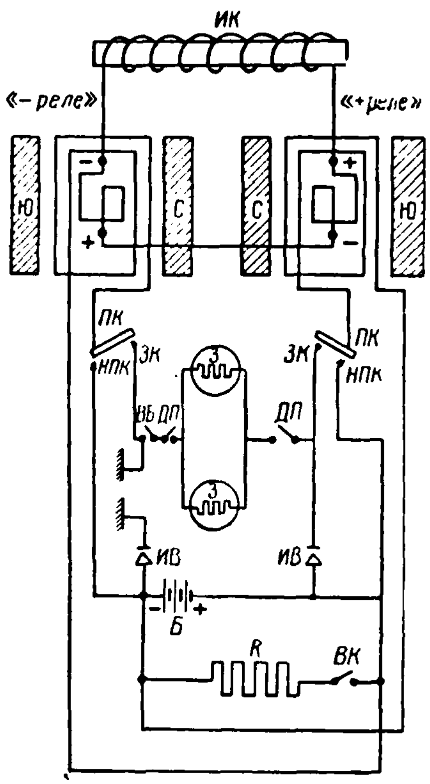

Fig. 49. Circuit of the Pistol-Duplex influence firing mechanism of a British torpedo.

Key: ИК -- induction coil; ВБ - battery switch; ДП remote safety switch; ВК - time contact; ИВ - inertia firing mechanism; Б - storage battery; R - discharge resistance; ЗК - detonator contact; НПК fixed spring contact; ПК - movable contact of relay; З - detonators.

The influence firing mechanism also switches in the group of movable contacts, the remote safety switch, the detonator and time contacts, the inertia firing mechanism (by construction and operating principle it is practically like the one we previously considered), the storage battery, the discharge resistance, and other elements.

When the torpedo passes close to the side of a ship an electromotive force of a certain direction is induced in the induction coil from the effect of the horizontal component of the ship's magnetic field /115
When the electromotive forces reaches a certain value it triggers one of the relays, e.g. "+relay" and the movable contact (ПК) "+ relay" becomes closed with the fixed spring by the НПК contact and the relay winding will be connected to the storage battery. At the same time the

movable contact (ПК) "+relay" will be closed with the detonator contact (ЗК). Now the movable contact (ПК) is the connector which joins detonator contact (ЗК) with the "+" of the storage battery ; the "-" of the battery is opened by the movable contact "-relay".

When the torpedo passes through the center line of the ship and electromotive force in the opposite direction is induced in the induction coil because the horizontal component of the magnetic field of the ship will change its sign (from "+" to "-"). When the value of the electromotive force reaches a certain magnitude it triggers the "-relay" and movable contact (ПК) connects the "-" of the battery with the detonator contact (ЗК). The circuit will be closed and an explosion will follow

The sequence of triggering a relay does not affect the operation of the firing mechanism. If the "-relay" was triggered initially the "+relay" will be triggered next.

For safety in servicing torpedoes and if the firing mechanism cannot be triggered near the firing vessel the firing mechanism has several safety devices, such as the remote safety switch (ДП), which is connected with the vane by a transfer system. Only when the torpedo passes through a certain dangerous distance does the remote safety switch from the vane close its own contacts. Now, if the torpedo passes close to the target the influence firing mechanism may be triggered.

If, for some reason, the vane was rotating on the ship, and the contacts of the remote safety switch were closed the magnetic field created by the passage of the firing ship near another ship may cause the firing mechanism to be triggered and an explosion is then possible.

In order to secure a ship against this eventuality a battery switch (ВВ) is provided in the circuit which has a movable pawl extending outside the torpedo shell. In the initial position it breaks the circuit from the "-" of the battery, just like the movable contact (ГК). On being fired from the torpedo launching apparatus the pawl thrusts against the cleat of the torpedo tube and is thrown back, thereby cutting in the battery switch.

If the torpedo has passed a given distance and has not struck the target the torpedo will sink and becomes a bottom influence mine. In view of the fact that the place where the torpedo sank is not precisely known it will be dangerous even for the firing ship because the torpedo might explode from its magnetic field. To avoid this a time contact (РК) is installed in the battery circuit which is connected with the timing mechanism. After a certain amount of time sufficient for the passage of the torpedo through a given distance the timing contact cuts in the battery to the discharge resistance R through which the battery is discharged. The torpedo is now completely safe, as far as the ship is concerned; even if it passes above it and triggers the relay no explosion will follow since the circuit has been rendered safe.

If, on approaching the target the influence firing mechanism has not been triggered for some reason but the torpedo has struck against the side of the ship-target, the explosion will nevertheless take place because the inertia firing mechanism will be activated, will close its own contacts, and the current from the battery will pass through the detonator (3).

The compressed air storage bottle is located behind the warhead. The air bottle is the central and largest section of the torpedo. It consists of a cylinder made of high grade steel with spherical shaped ends. The container is filled with compressed air for operating the main power plant in the torpedo and its other mechanisms.

The air from the air bottle (fig. 50) enters the engine and mechanisms through an opening in the after bottom to which an air line is connected. There are several valves on the air line. The inlet valve permits the compressed air to be pumped into the tank and the locking valve prevents air from escaping out of the container when the torpedo mechanisms are not operating.

In order that the air may g from the air container to the main power plant it is necessary in addition to the locking valve to open the engine valve; the latter is opened only when the torpedo is fired from the torpedo launching tube. It is connected by a special rod to the torpedo tripping lever which is thrown back by the tripping lever cam of the apparatus the moment the torpedo leaves the launching tube. The way is now clear for the air from the air bottle. /117

Air under such high pressure may not be fed into the main engine due to the danger of rupturing the cylinders; furthermore the output of such an engine would be quite uneconomical. Accordingly, it is necessary to reduce the air pressure and that takes place in the stern portion of the torpedo.

The stern or after portion, consisting of several compartments, is located behind the compressed air bottle. The principal mechanisms of the torpedo are contained in it.

Let us consider the Mk-15 (fig. 45), an American torpedo in which the after section is divided into three parts. Located in the first section alongside the air bottle is a small tank for kerosene and a compartment with water. The kerosene and water are forced out by the air and enter the high pressure air preheater when the torpedo is fired.

The kerosene and water are necessary to obtain a mixture of steam and gas during the period of operation of the steam turbine or engine.

To insure constant torpedo speed it is important that the air enters the main engine at a uniform rate during the operating period and at a precisely set pressure. Reducing valves lower the air pressure to the necessary level. Spring loaded valves act as regulators. The pressure of the entering air and, therefore, the speed of the torpedo is regulated by changing the compressive force on the spring. One, two, or three fixed speeds are set for each model of torpedo. Ordinarily, two regulators -- high and low pressure -- are used. The first reduces the pressure from 200 to 50-60 atmospheres, and the second reduces it from 50-60 to 20 or 30 atmospheres, i.e. to a pressure necessary for the operation of the engines.

The air from the reducing valves goes to the preheater which looks like a small pot with a lid. The water, kerosene, and air from the reducing valves enter through passages in the cover. When the torpedo is released the igniter located on the cover of the preheater is ignited. The kerosene atomized by the compressed air is inflamed by the igniter, greatly raising the temperature in the preheater. The water entering the preheater turns to steam which, when mixed with the products of combustion, forms a steam-gas mixture.

The resulting steam and gas mixture goes from the preheater to the turbine blades to do useful work.

Use of a steam-gas mixture permitted reducing the consumption of air; this gave the torpedo additional reserves of energy and made for greater range and speed. /118

Piston engines are used in many torpedoes. The gas-steam mixture goes into the main engine cylinders. The two cylinder horizontal engine is very similar to the ordinary steam engine. Each cylinder has a piston with a rod which moves forward and backward under the infleucne of the steam and gas mixture. The translatory motion of the pistons is converted into the rotary motion of propeller shafts and screws through the connecting rod and crank mechanism.

Slide valves are arranged beside the cylinders to insure the uninterrupted operation of pistons and propeller shafts connected to them and for the timely injection and discharge of the steam and gas mixture. The torpedo is equipped with two hollow shafts, one contained inside the other. A propeller is inserted on the end of each shaft.

The spent gases from the main engine pass through the internal hollow, brass propeller shaft and are exhausted to the exterior, leaving a tell-tale foamy wake on the surface.

The main engine of modern torpedoes can develop, despite its small dimensions, great power (up to 500 h.p.); this is equal to the output of two small tugboats or nine Pobeda automobiles. A turbine is contained inside the second stern compartment of the Mk-15 torpedo. In this case the steam and gas mixture from the combustion chamber enters through the nozzles and impinges against the turbine blades in which heat energy is converted into mechanical energy, i.e. the turbine rotor is caused to turn (fig. 51). The rotary motion of the rotor (fig. 52) is transmitted via a system of gears to the two propellers of the torpedo.

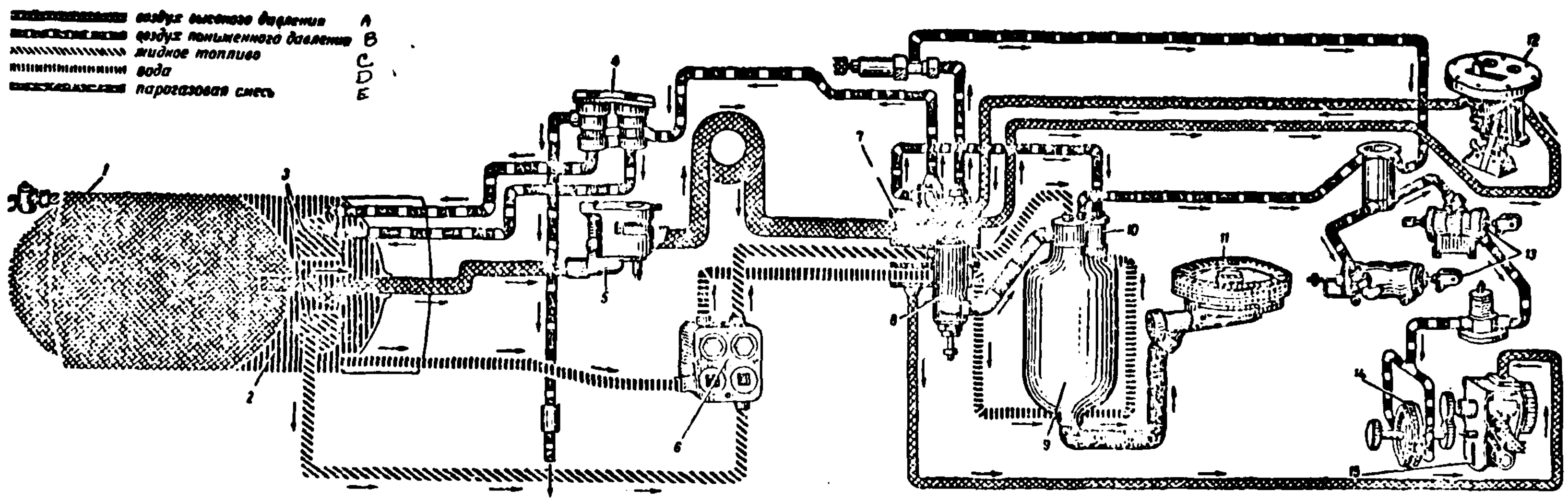

Fig. 50. Schematic diagram of air, water, and fuel flow channels to Mk-15 torpedo mechanisms:

1. Air bottle; 2. water compartment; 3. kerosene tank; 4. valve for forcing out water and fuel; 5. inlet and shut-off valves; 6. fuel and water filters; 7. engine valve; 8. engine pressure regulators (reducing valves); 9. preheater with igniter (10); 11. turbine; 12. starting valve tripping lever; 13. steering engines; 14. gyroscope and starter turbine (15); a. high pressure air; b. low pressure air; c. liquid fuel; d. water; e. steam-gas mixture.

The third compartment contains mechanisms which operate the torpedo rudders while it is in motion. A hydrostatic device which holds the torpedo at a given depth throughout its run operates the horizontal rudders and a gyroscopic device operates the vertical rudders. It corrects any deviation to the right or left of the present course.

An important component of the hydrostatic apparatus (fig. 53) is a movable bronze disk with spring covered over with a rubber diaphragm that protects the torpedo from the entry of seawater. The movable hydrostatic disk "senses" changes in the external water pressure and reacts to them. /119

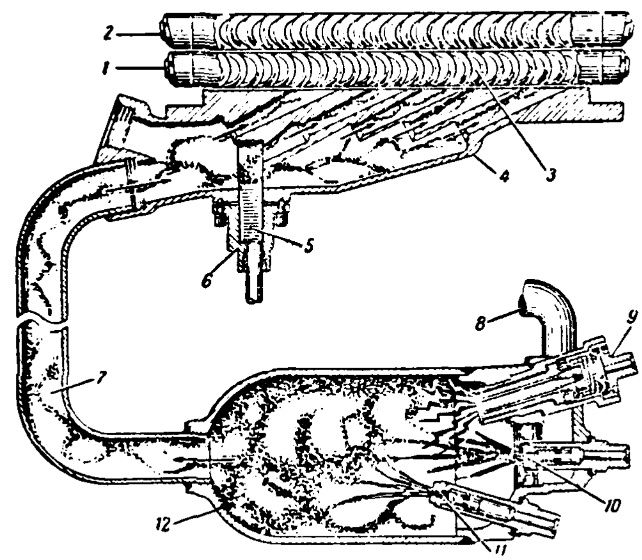

Fig. 51. Path followed by air from the preheater to the turbine:

1. First turbine wheel; 2. second turbine wheel; 3. blade; 4. nozzle; 5. nozzle valve; 6. valve union; 7. gas to nozzle; 8. air entering preheater; 9. igniter; 10. stream of atomized fuel (fuel injector); 11. stream of water; 12. combustion chamber.

The disk with diaphragm is tightened on one side by a spring and the pressure of the air in the compartment and on the other side of it is under the pressure of the water. ne work of the hydrostatic apparatus is based on an equilibrium of two forces: the force of pressure of the external water column and the spring pressure on the movable disk inside the torpedo. If the force of the spring is equal to the pressure of the outside water on the hydrostatic disk the sliding valve of the rudder motor and the rudders occupy the middle position. /120

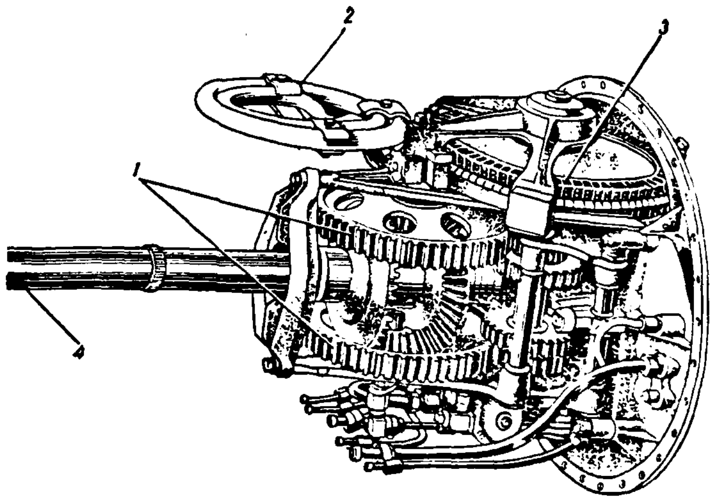

Fig. 52. Main turbine engine.

1. Main drive gears; 2. air tubes; 3. turbine; 4. propeller shafts.

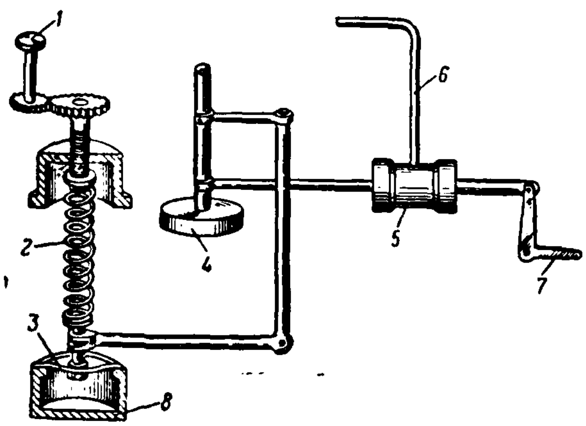

Fig. 53. Diagram of hydrostatic equipment:

1. Depth setting screw; 2. spring; 3. diaphragm; 4. balancer: 5. steering engine; 6. air line; 7. horizontal rudders; 8. hydrostatic disk.

If the torpedo is traveling below a set depth the pressure of the outside water will overcome the resilient force of the spring. The hydrostatic disk will shift and the slide valve associated with it will admit air into the cylinder of the steering engine. The steering engine piston will move and with the aid of pull rods will transpose the horizontal controls upward. The torpedo will begin to surface. When the torpedo approaches the prescribed depth the rate of rise will be so great that the torpedo will necessarily pass beyond this depth. As it does so, the pressure of the water on the hydrostatic disk will decrease. The spring will move the disk and, therefore, the slide valve in the other direction and the steering engine will transpose the controls downward. The torpedo will begin to dive.

With such correction for the depth the torpedo will make sizable deviations from the preset level and will continuously slip past the required depth (fig. 54).

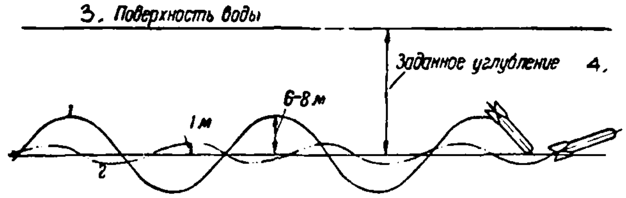

Fig. 54. Depth trajectory of torpedo run:

1. Path of torpedo without pendulum; 2. path of torpedo with pendulum; 3. water surface; 4. prescribed depth.

In order to reduce torpedo yawing in depth it was necessary to install a pendulum (fig. 53) in the hydrostatic instrument. The balancer holds a vertical position and is connected to a rod which transmits the stress of the spring to the hydrostatic disk. A lead weight is secured to the base of the balancer and imparts greater sensitivity to the hydrostatic device.

If the depth of the run will change markedly, i.e. if the torpedo deviates considerably from its horizontal position, the pendulum will overcome the resiliency of the hydrostatic spring by the force of gravity and will depart from its initial middle position. Its movement will shift the slide valve of the steering machine, the horizontal controls will shift under the influence of the air, and the torpedo will again move at the preset depth.

The pendulum accelerates the transposition of the rudders when the torpedo departs from the preset depth and inhibits the rapid transposition of controls when the torpedo returns to the preset depth, thereby correcting the motion of the torpedo. The path of the torpedo in this case will be more direct than without the balancer. Deviation from the prescribed depth in this case is not over one meter. /122

In fire at enemy ships a certain running depth, depending on the target ship's draft, is set for the torpedo. For example, in fire upon battleships with a draft of between 10 and 12 meters the running depth of the torpedo is set for 8-10 meters, and in fire at destroyers with a 4-6 meter draft the torpedo running depth is set for 2-4 meters. The torpedo running depth is set by changing the tension of the hydrostatic disk spring by means of a depth setting screw.

Fulfilling only one condition -- observing the prescribed depth -- is not of itself sufficient for a successful attack because the torpedo, even though it has maintained the depth, may swerve from its heading and miss the target. It is necessary to have an automatic pilot which will hold the torpedo on a set course during the run. This automatic pilot is a gyroscopic instrument which transmits a command to the vertical rudders which hold the torpedo on the preset heading. The gyroscopic instrument consists of a spinning top, a device for starting it, and a steering motor which transposes the vertical rudder.

The operating principle of a gyroscopic instrument is based on the property of a gyroscope axis roataing at great speed to maintain a fixed position in space, a fact explained by the high centrifugal force of a rapidly rotating body. This force holds the gyroscope shaft in a direction which it held when started and helps to counteract any force attempting to deflect it from a preset direction. In the torpedo the spinning top is secured in a so-called universal suspension consisting of two rings -- horizontal and vertical -- one secured inside the other (fig. 55).

The vertical and horizontal rings of the universal suspension device rotating on their individual axes enable the gyroscope to maintain a fixed position in space -- a position held at the time the torpedo was ejected.

The axis of the spinning top before ejection is connected to the axis of the starter turbine. In order for the torpedo to hold a preset heading the axis of the spinning tope should be parallel to the axis of /123
the torpedo and the vertical ring should be perpendicular to it.

As the torpedo moves through the launching tube during the firing process, the tripping lever of the starting valve is tilted and the highly compressed air passes to the turbine which activates the gyroscope, imparting to it a speed of 20,000 to 30,000 rpm.

Before the torpedo emerges from the tube the impeller shaft disengages from the shaft of the gyroscope top. To keep the gyroscope top rotating at a high rate of speed inclined grooves are made about its periphery similar to the blades in a turbine to which low pressure (20-30 atmospheres) compressed air is applied. /124

If the torpedo begins to depart from the target course due to external forces attempting to deflect it from the course it will begin to turn the body of the gyrsocope instrument and the steering motor, while the spinning top and the vertical ring will hold their original position. The vertical ring is connected with the aid of an eccentric to the slide valve of the steering motor, therefore when the torpedo axis turns relative to the vertical ring the slide valve will shift and permit compressed air to enter the cylinder of the steering motor, and this transposes the vertical rudders. Through the action of the rudders the torpedo will return to its original position, the axis of the spinning top will again become parallel to the torpedo axis, the vertical ring will shift the eccentric and the sliding valve will close the access hole to air into the steering motor, and this will set the vertical rudder in the middle position. In the process, of course, the torpedo will not ravel a straight line but along a smooth curve because the vertical rudders are at all times being shifted from their middle position to the right and to the left.

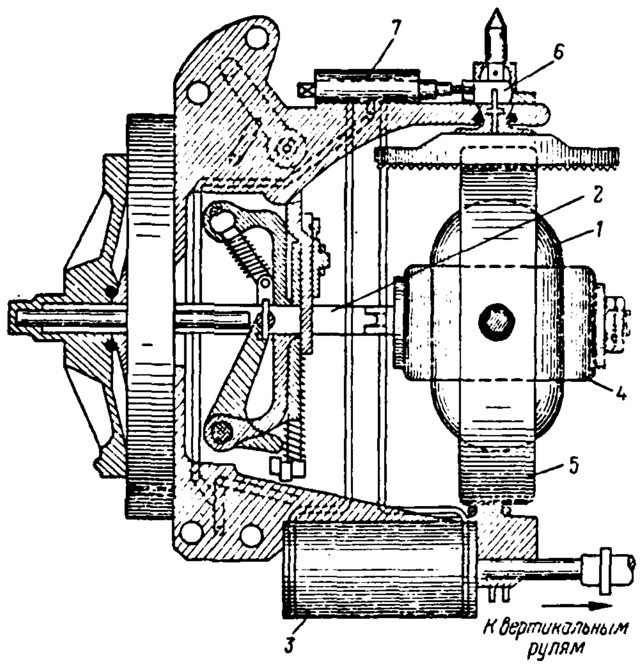

Fig. 55. Torpedo gyroscopic instrument:

1. Spinning top of gyroscope; 2. starter turbine shaft; 3. steering motor; 4. horizontal ring; 5. vertical ring; 6. eccentric; 7. steering motor slide valve.

The tail of the torpedo consists of the tail vane, two propellers, and horizontal and vertical rudder controls. The tail serves to impart stability of motion in the water and to control the run with respect to depth and direction by means of rudders.

Ordinarily, two propellers are contained in the frame of the tail; they are coaxially arranged, one turning clockwise and the other counterclockwise. Rotating in different directions, given equality of torque of both screws, they exclude any possibility of the torpedo turning about its own axis due to torque and, consequently, deviation by the torpedo from its heading. Various types of torpedoes have propellers with two, three, and even four propeller blades.

For many years designers and engineers along with torpedomen have been trying to findsome method of equipping a torpedo with an electric motor. The idea of using electricity to power a torpedo was very intriguing. Some years ago mines were detonated by an electric current but the current to the mine fuze was transmitted by cable from a shore based battery. Somewhat later electrical energy was used not only to ignite the explosive but also to propel the torpedo and operate its controls. /125 But even in this case the source of power was not in the torpedo itself but on a ship and the current was transmitted by a cable connected to the torpedo. Since the torpedo had negative buoyancy in this case (it was heavier than water) it was necessary to attach floats to it. The torpedoman on the ship controlled the torpedo heading, watching the floats, and he closed the igniter circuit when the torpedo impacted against the target ship.

It can easily be seen that an attack by such a torpedo was not very effective because as the torpedo widened the distance from the ship the enemy could discern it more readily than could the torpedoman. In addition, the floats constituted a good target which could be hit very easily. Obviously, torpedoes of this type were never adopted. For a long time attempts to design a small sized package of power which could be accomodated inside a torpedo were unsuccessful.

During World War II the fleets of Germany, the United States, and other nations had electric torpedoes as organic equipment in which a storage battery was used as a source of electrical power for operating a motor. These torpedoes were initially fired from submarines; in fire from surface vessels the torpedo was subjected to a rather powerful impact on entering the water and this put the batteries out of operation. Later on a better designed battery was used and small dimensioned torpedoes appeared which could be fired not only from surface vessels but could also be dropped by aircraft.

Compared with steam and gas torpedo the electrical variety has some important advantages: it does not leave a visible wake behind it, thereby insuring concealment for the submarine at the instant of launch; while in motion the electric torpedo holds a preset heading more steadily because in contrast to the steam and gas torpedo it does not change its weight nor the position of its center of gravity (there is no expenditure of air, water, or kerosene). In addition, electric torpedoes produce comparatively little power plant and instrument noise, a fact of special worth for submarine launched attacks.

But the electric torpedo also has some considerable shortcomings: in contrast to the steam and gas torpedo it is much slower and has a shorter range.

However, despite this, the electric torpedo won great popularity in the fleet. At the present time foreign naval fleets have many electric torpedoes of various types, but for the most part they have the same kinds of mechanisms and assemblies. Let us consider the U.S. Mk-18 electric torpedo (fig. 56).

Fig. 56. The U.S. Mk-18 electric torpedo.

1. Explosive; 2. igniter; 3. storage batteries; 4. electric motor; 5. engine starting switch; 6. hydrostatic instrument; 7. gyroscopic instrument; 8. vertical rudder control; 9. forward screw; 10. after screw; 11. horizontal rudder control; 12. air bottles; 13. hydrogen burning device.

Like its gas and steam counterpart the electric torpedo consists of four basic parts: the warhead, storage battery compartment, the afterbody, and the tail section.

In the electric torpedo there are gyroscopic and hydrostatic instruments and steering motors, just like the steam and gas torpedo. The power plant in the electric torpedo is a motor operating from the electric energy provided by the storage battery located in the storage compartment. This is the largest compartment and makes up about one-half of the weight of the torpedo.

Located in the storage battery compartment are the series connected oxygen-lead battery cells. The energy reserve of oxygen-lead batteries is not very great and the maximum range of the electric tc [illegible] un is about 4,000 meters at a speed of about 30 knots.

It is a known fact that a storage battery gradually becomes discharged: inside the battery there is a continuous chemical reaction with a slow discharge of hydrogen which enters into the storage battery compartment. Until the torpedo is loaded into the torpedo tube the discharged hydrogen can readily be removed by opening the storage battery compartment ventilating handhole. /127

Combining with the air contained in the compartment the hydrogen forms an explosive mixture. If the hydrogen penetrates into the compartment in which the engine is contained an explosion can result instantaneously from the smallest spark. Cases of torpedo explosions have been numerous. It is quite difficult and inconvenient to haul out the torpedoes from tubes periodically to open up their ventilating holes to release the hydrogen. Therefore, various instruments are placed inside the torpedoes to eliminate the hydrogen that has formed (by burning, ventilating, etc).

A hydrogen suppressor is contained inside the storage battery compartment of the torpedo under discussion and its spiral is connected to the electric power supply sourced of the submarine. When the spiral become heated the liberated hydrogen combines with atmospheric oxygen, burns, and forms water vapor.

If the hydrogen suppressor is connected before a dangerous concentration of hydrogen accumulates in the storage battery compartment, the combustion reaction of hydrogen will be so much slower that the danger of an explosion is excluded. An air tight bulkhead is provided at the end of the storage battery compartment to prevent the hydrogen that is continuously being given off from penetrating into the stern section.

For a torpedo to travel to its target ship unobserved it is essential that there be no traces of any kind astern of it. But there are air tanks in the torpedo to operate the gyroscope, hydrostat, and the steering mechanism actuators. Will not this air reveal the path of the torpedo? The spent air is discharged into the tail section rather than to the outside. The pressure of the spent air in the stern section gradually increases in the process,but in order for it not to become excessively high (with the possibility of rupturing the torpedo shell) a one-way safety valve has been inserted in the bulkhead to scour the air in the storage battery compartment . When the air pressure in the tail section exceeds the air pressure in the storage battery compartment the valve opens and the air passes into the storage battery compartment. The pressure in the stern section is gradually reduced, and the valve again closes. In this case the air goes through the airtight bulkhead in only one direction: from the stern section to the battery compartment. This is /126
insured by the one-way safety valve.

Installed in the forward part of the tail section compartment on the side of the battery compartment is a six-pole direct current 90 h.p. motor. The electric motor enables the torpedo to develop top speed immediately after it has been fired.

On firing the torpedo the tripping lever is thrown back and the high pressure air from the air bottles flows in three directions: to the starting switch, the gyroscope, and the regulators which reduce the pressure of the air. The contacts of the starting switch are closed by the force of the compressed air which connects the engine circuit with the storage battery; the gyroscope is started and the low pressure air enters into the steering mechanism of the hydrostatic and gyroscopic devices. The construction of the other assemblies and mechanism of an electric torpedo are similar to those of the gas and steam torpedo, hence we shall not dwell upon them.

To increase the speed and range of an electric torpedo scientists of many countries are at work trying to develop new capacitive sources of electric power which might replace the heavy oxygen-lead storage batteries.

According to the publication "Missiles and Rockets", silver-zinc storage batteries have been developed whose specific power is three to four times greater than the specific energy of lead batteries, a fact which permits increasing the speed and range of the torpedo considerably. However, the cost of such batteries is approximately ten times greater than the cost of lead type storage batteries. At the end of World War II there was a report to the effect that German submarines were carrying acoustic type target seeking torpedoes which homed in on the sound of a ship's propellers.*

* This was the first modern guided missile which anticipated its air counterparts by several years; despite the fact that it operates under water exclusively, its accuracy is by no means inferior to that of guided missiles.

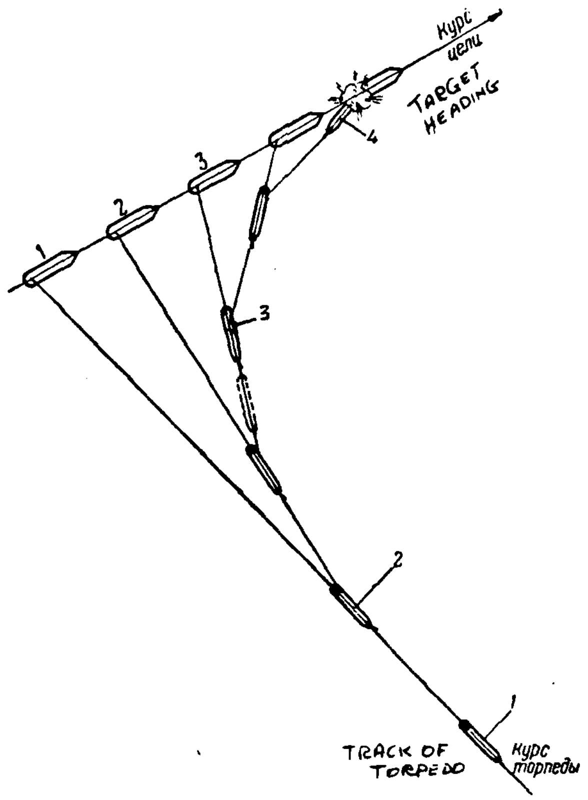

Fig. 57. Diagram describing the motion of a homing torpedo:

1. Torpedo on course indicated by gyro; 2. noise on right hydrophone greater than on left hydrophone: homing system turns rudders to right; 3. noise on left and right hydrophones equal: rudders in center position; 4. torpedo has caught up with target.

The target seeking torpedo is an electrical powered weapon equipped with acoustic gear. In contrast to previously existing torpedoes the homing variety seeks out its own target. If the target is within the operating limits of the homing apparatus the torpedo will begin to guide itself upon it (fig. 57). If the target ship attempts to take evasive action against the torpedo the latter will begin to follow and then catch up with it. /130

Just how does a target seeking torpedo search out its target and communicate the direction of the target to its own instruments? All known homing torpedoes are of the acoustic variety. They are provided with special instruments which are capable of catching sound vibrations from the target, converting them into electrical signals and then amplifying them to a certain magnitude. The amplified signals control the torpedo rudders and guide it to the target ship. Acoustic systems of homing torpedoes may be active or passive.

A torpedo with an active acoustic homing system transmits sound pulses and if there is a target within the operating limits of the homing system these pulses hit the target and are reflected back to the torpedo. Consequently, the torpedo is guided to the target by the reflected sounds.

A torpedo with a passive acoustic target seeking system does not transmit any sound (except, of course, the noises of its own engine and propeller). The system itself picks up the sounds from the propellers and engines of the target ship and insures that the torpedo will move toward the source of noise.

In order to pick up sounds whose frequencies are outside the range of audibility of the human ear the equipment contains special devices called transducers. These devices perceive the energy of sound oscillations and convert it into electrical energy. The most simple type of transducer for underwater operation is the hydrophone, which catches underwater sounds transmitted from the target ship or sounds reflected from it. The hydrophone, an electrodynamic transducer, is widely used at the present time. The hydrophone diaphragm oscillations are transmitted to a movable coil which cuts across the magnetic field of a bias winding. An electromotive force is induced in the coil which is the command electric signal that controls the torpedo rudders.

Since mechanical and electrical oscillations in hydrophones are reversible the latter can be used as an underwater source of sound radiation. This property of reversibility is widely used where one and the same element can alternately serve as a hydrophone and as a sound radiator.

Receiving and converting sound into electric signals which control rudders, hydrophones, and other equipment insures the torpedo run to the source of the sound.

A target seeking torpedo has a warhead, storage battery compartment, afterbody, and tail section. The construction of all compartments, with the exception of the warhead section, is basically the same as in the electric torpedo. In the warhead compartment there is a bay in which the principal homing instruments are contained.

The gyroscopic and hydrostatic instruments in most homing torpedoes are of the same type as in the electric torpedo. In some homing torpedoes the top of the gyroscope is caused to rotate by an electric motor rather than by compressed air. Torpedoes of that type have no air tanks because all the instruments which control the motion of the torpedo are electrical.

Command signals from gyroscopic and hydrostatic instruments do not enter via a mechanical drive as is the case in a steam-gas torpedo but through a relay to solenoids which control the rudders.

Compared with the mechanical drive of the gas-steam torpedo electrical instruments have a number of advantages. They do not require compressed air, are accurate and reliable in operation, and what is very important in a homing acoustic torpedo, are practically noiseless. The homing torpedo directs itself to the source of noise and in order not to introduce sensitive interferences into the acoustic homing system it should make as little noise as possible.

Hydrophones are installed in the forward part of the warhead. The right and left hydrophones control the homing system of the torpedo in the horizontal plane (they control the course of the torpedo), and the upper and lower hydrophones control the torpedo homing system in the vertical plane (they control the torpedo depth of run).

After a passive homing torpedo is fired at a ship target and the hydrophones pick up noise from working propellers the noise thus received is converted into a pulsating low amplitude electric current. The currents from the two hydrophones (right and left) enter the amplifier where they are amplified and compared for magnitude. If the received noise in the left hydrophone is greater than in the right the current in the left hydrophone will be greater than in the right. The amplified command signal from the left hydrophone goes to the actuating mechanism which turns the vertical rudder to the left. The torpedo will turn to the left toward the source of noise given off by the target ship. /132

If there is no ship-target in the operating range of the homing apparatus the gyroscope controls the course of the torpedo and the hydrostatic instrument holds it at the preset depth. For example, if the target is located to the right of the torpedo course in the operating zone of the homing apparatus the noise from the target in the right hydrophone will be more powerful than in the left. The homing equipment will then open the gyroscope circuit which will no longer hold the torpedo on the preset course and will turn the vertical rudder to the right. The torpedo will veer from its course to the right until the ship target is directly in from of it. The noises in the hydrophones and, therefore, the currents at their outputs will become the same and will mutually compensate one another. The command signals will not go to the actuating mechanism and the vertical rudder will assume the middle position.

Thus, the homing torpedo automatically corrects its course toward the target. Because of inertia and a certain delay in transposition of the rudders it will slip past its course when the noises in the hydrophones are of equal strength. Therefore, the vertical rudders will continuously deviate from their middle position, receiving command signals from the right and then from the left hydrophones. Can a homing torpedo "hear" the noise of a ship firing and turn toward it? No, it cannot.

Homing torpedoes have various kinds of devices which protect the ship against explosions of their own torpedoes. For example, in some foreign models of homing torpedoes the influence or inertia firing mechanism is safe at a range of 200-400 meters from the firing ship and will not cause an explosion even if the torpedo hits a target. After traversing this distance the firing mechanism, which is linked by greats with the safety vane, becomes armed.

Some homing torpedoes have a device which opens the homing circuit at the beginning of the run. The gyroscopic instrument holds the torpedo on the preset course and does not allow it to deviate even if it is passing near the target, the source of the noise. Not until it has traversed the dangerous part of the run are the homing circuits switched in. This eliminates the danger of the torpedo homing in on the firing ship.

The torpedo rudder rarely remains in one position for more than /133 one or two seconds. If it remains in the same position long enough for the torpedo to turn as much as 90° it may hear the noise of its own ship in the dangerous distance area and home in on it. To avoid this some torpedoes have a device which registers the time during which the vertical rudder is deflected from the middle position. If this time exceeds an established value the instrument cuts out the engine and the torpedo sinks. If the torpedo has passed the dangerous distance the instrument is switched off and it can safely turn back.

Homing electric torpedoes have increased the target probability considerably. During World War II German submarines armed with acoustic homing torpedoes sank numerous Anglo-American ships. The following incident involved a British destroyer. The acoustic torpedo fired from a German submarine missed the target, a destroyer, which was traveling at nominal speed. Seeing this, the destroyer captain ordered an increase in speed to attack the submarine with which sound contact had been established. Howeve , at this very moment the torpedo unexpectedly veered off its course and struck the destroyer in the ammunition magazine. In a few second the ship disappeared into the sea. It is not easy to find an effective means of counteraction against an acoustic torpedo.

To avoid being hit, a ship-target apparently should turn toward the torpedo and cut off its engines, or retreat before it if the ship's speed is greater than that of the torpedo. However, to execute these maneuvers much time is required, and a torpedo attack is a fast moving action. Furthermore, a homing torpedo is wakeless: nothing betrays its movement and it is understandable how difficult a problem it is for the ship to spot and evade the torpedo.

TORPEDO TUBES

Before a torpedo begins its run to the target certain values have to be fed into its instruments; it then has to be aimed and fired. Torpedo tubes or launchers have to be installed to perform these operations. /134

Torpedo tubes are used to accomodate torpedoes and, until they are fired, to protect them from impact, penetration of water, and the like. Located on the torpedo tube are instruments by means of which all the necessary settings are introduced into the torpedo. By rotating the torpedo launcher the torpedo is given the proper heading toward the target and the launching system expels the torpedo. The launcher consists of one or several tubes which are subdivided into underwater and surface types.

These launchers are mainly used on destroyers and torpedo boats. Surface launchers may be rotatable or fixed. The rotatable torpedo launcher
pies much space on the ship's upper deck. Therefore, to accomodate
uch artillery on the upper deck as possible some of the new destroyers
reign navies are being equipped with fixed torpedo launchers which
signed, mainly, for firing electrical homing torpedoes; they may
nsist of one, two, or more tubes arranged inside the ship's superstructure.

On a torpedo boat the tubes of the launchers are also fixed; they are located along the sides. The boat's course imparts the necessary target direction to the torpedo.

Rotatable launchers (fig. 58) consist of the following basic parts: the base, rotating platform, tubes, horizontal aiming mechanism, and instruments for setting the course of the torpedo, the gyroscope angle, and the depth of the torpedo run.

The equipment base consists of a steel drum located underneath the torpedo launching tube rigidly secured to the ship's deck. There are grooves with balls in the upper part of the base for turning the rotating platform to which are secured the steel tubes of the launcher. The cylindrical tubes are made of thin sheet steel. The pressure inside the tube which develops on firing is not too great and is designed merely to expel the torpedo out of the launching tube. The torpedo tube reminds one of a gun barrel. It forms a closed chamber in which powder gases or compressed air expand on firing. The torpedo is ejected from the launching tube by the force of the gases (fig. 59).

The tube directs the torpedo in the required direction, insures the flight of the torpedo above the deck of the ship, and imparts the necessary angle of entry into the water. A T-shaped groove is contained in the /136 upper internal part of the tube through which the guide stud of the torpedo moves. The T-shaped groove prevents the torpedo from turning inside the launcher tube, and on firing it insures the necessary angle of torpedo entry into the water. Access holes with covers for servicing torpedo mechanisms are arranged along the length of the tube.

In the rear portion the tube is covered with a watertight cover which can be opened when loading the torpedo, for making inspects, etc. There is a closed space between the cover and the stern portion of the torpedo for the admission of gases which eject the torpedo from the launching equipment.

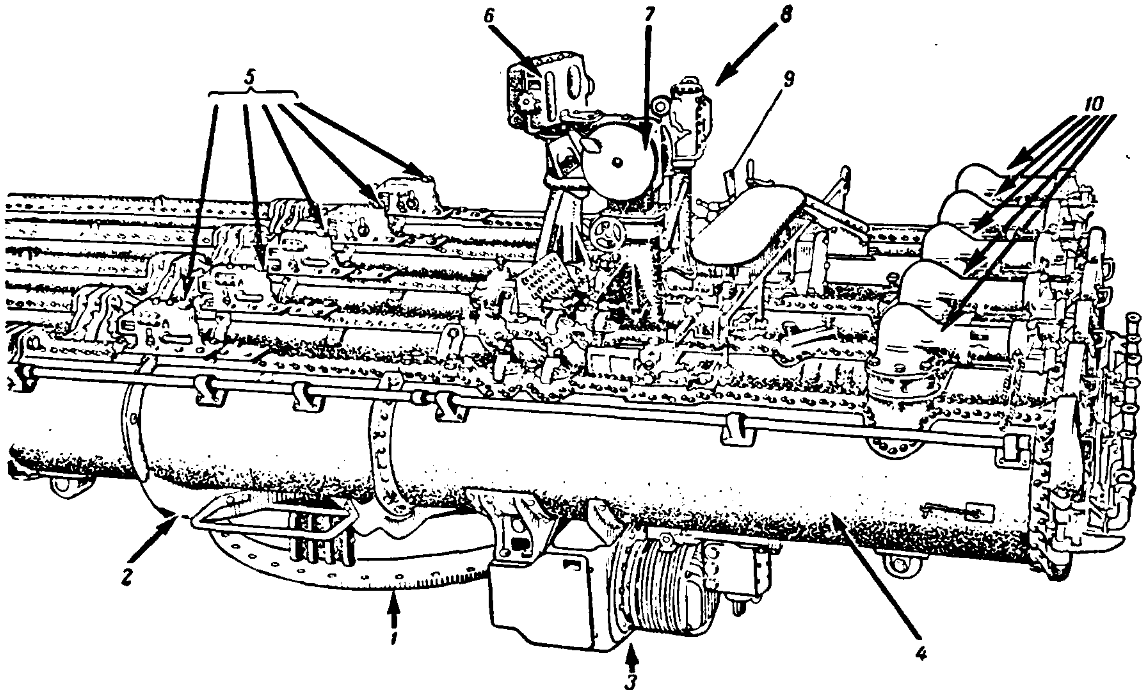

Fig. 58. American five-tube surface torpedo launcher with instruments and mechanisms.

1. Equipment base; 2. rotatable platform; 3. electric motor with drive; 4. tube; 5. stopping mechanisms to hold the torpedo in the launcher; 6. torpedo course instrument; 7. horizontal aiming device; 8. torpedo gyroscope angle setting instrument; 9. instrument for setting torpedo depth of run; 10. firing mechanisms (breech chambers).

To keep the torpedo from shifting along the tube when the ship is rolling and pitching there is an arresting mechanism on top of the tubes. This d vice has stops extending into the interior of the tube which hold the torpedo in a certain position by means of studs.

The horizontal aiming mechanism (fig. 60) with electric or hydraulic drives is used for training the launching tubes at the target. The aiming process is performed by the tube operator who controls the electrical or hydraulic drives by rotating a handwheel and turns the launcher in one /137 direction or another. If the electrical aiming device of the launcher has become inoperable the launcher can be turned manually.

Fig. 59. Torpedo leaving launching tube

The guns, houses, and various compartments are located on the upper deck, therefore the torpedo launcher can only be turned through a certain angle. However, during torpedo fire it may become necessary to expand the arc of fire. For this purpose there is an instrument on the torpedo launcher for setting the gyrsocope angle. Inserting the gyrsocope angle in the torpedo causes it to turn right or left of the original launcher set direction after it is fired. The torpedo launcher is equipped with a torpedo depth of run setting instrument also.

Depending on the firing range the speed mechanism permits setting one of three speeds in the torpedo: maximum, medium, or slow speeds. All these instruments are serviced by the setter.

The gyroscope angle scale and the spread angle scale (the angle between two adjacent torpedoes in a salvo) are located in front of the setter. /138 On obtaining these data from the torpedo fire control instruments the setter proceeds to introduce them into the torpedo.

In order that the engine and gyroscope begin operating immediately on firing the torpedo it is necessary to pull back the torpedo starting lever. For this purpose there is a tripped on the launching tube which is lowered into the tube before firing. As the torpedo moves in the tube the starting lever goes on the tripper and is pulled back, thereby activating the engine and main instruments.

Each tube has its own firing mechanism -- the powder chamber. The powder chamber usually consists of the chamber into which the powder charge is placed, the breech, and the trigger mechanism. Firing is usually accomplished by electrical or percussion methods. In some torpedo launching equipment firing is accomplished by means of compressed air contained in tanks.

Instruments are set up on the launching equipment in front of the tube operator by which he aims the launching tubes. In the event the torpedo fire control instruments fail to operate the tube operator aims the launching equipment at the target using the sighting device.

Underwater torpedo tubes are installed in a rigid position in submarines. Their mechanisms are more complicated than those in the surface launching tubes because they are designed for fire under water.

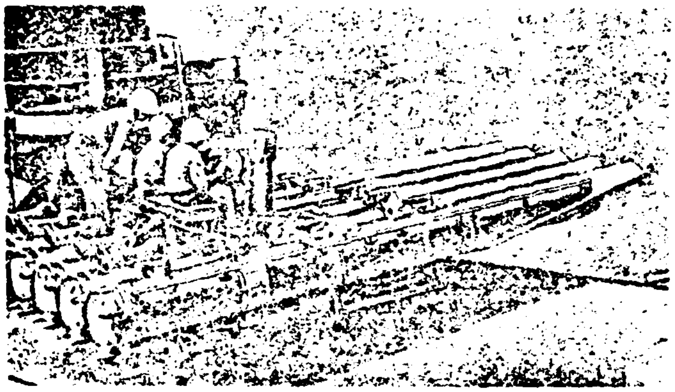

Fig. 60. Five tube surface type rotatable torpedo launching system ready for firing.

The submarine torpedo tube has mechanisms for opening and closing the front and rear tube shutters, gyroscope angle setting instruments, depth and speed setting instruments, and a system of valves which fills the torpedo tube with water before firing and drains them after firing.

The tubes are closed at both ends with shutters. The rear shutter opens into the submarine torpedo compartment, and the forward shutter opens directly into the sea. If both shutters are opened simultaneously seawater will gush forth into the torpedo compartment. In order to prevent this the torpedo tube is equipped with blocking mechanisms which prevent the simultaneous opening of the forward and rear shutters.

When the submarine is in a deep dive the forward shutter is subjected to tremendous pressure by the surrounding water. Individuals are powerless to overcome such great resistance and power systems are helpful in this regard. A hydraulic drive is ordinarily used in submarines to open and close the forward shutter. /139

Both shutters are closed before a torpedo is loaded into the launch tube. A special valve is then opened and water is expelled from the tube by a special valve. After the water has been removed the rear shutter is opened and the torpedo is loaded into the tube. Following that the shutter is closed again and the tube is filled with water, not seawater but water from a tank. The forward shutter is now opened and the equipment is ready for firing. If the forward shutter is opened before water completely fills the tube, the seawater, which pushes into the tube with force, could damage the torpedo's rudders and propellers.

Before pressing the firing button the highly compressed air from the special tanks enters into the rear space of the tube, overcomes the pressure of the seawater, and forces the torpedo out of the tube. The compressed air which ejects the torpedo does not leave the tube to the water surface but enters a special tank inside the submarine. This insures security in firing. Two types of devices -- piston and non-piston -- are used for bubble-free fire in a submarine.

In the first case a piston plunger is placed in the stern portion of the torpedo tube. In firing, air under great pressure enters the space between the rear shutter and the piston and moves it forward together with the torpedo. After the torpedo leaves the tube the air between the rear shutter and piston goes to the reservoir in the submarine while the piston is returned to its original position due to the force of the seawater. The piston system is clumsy and complicated, hence it is almost never used now.

In the second case the compressed air which forces the torpedo outward leaves the tube through a one-way valve into the reservoir inside the submarine before it gets to the forward shutter of the tube. Therefore, no signs or traces appear on the ocean surface and concealment of the submarine and the torpedo attack are maintained.

As soon as the torpedo leaves the tube the latter is quickly filled with seawater. After closing the forward shutter, the tube is drained again, the after shutter is opened, and another torpedo is loaded into the tube.

After the torpedo is fired the submarine becomes lighter by the weight of one torpedo. In order that the submarine maintain the previous weight distribution there is a special tank which is filled with seawater by an amount equivalent to the weight of a torpedo.

Present day larger sized submarines have ten or more torpedo tubes. They are fixed and are part of the submarine hull, therefore the torpedoes are fired by aiming the submarine at the target or by introducing a gyro angle into the torpedo.

Before firing the torpedomen check the operating conditions of the torpedo and launching tube mechanisms. On determining that the instruments and mechanisms are in good working order the torpedo is loaded into the tube and the necessary settings are made. But in order for the torpedo to hit the target it is not sufficient merely for the torpedo and tube to be in proper working order. It is also necessary to perform a third and final phase in firing, and that is to determine the heading for the torpedo which will insure a hit upon the target. Actually, the smallest error or inaccuracy commited in computing the heading for the torpedo will make the final attack fruitless; the torpedo will maintain the preset heading, depth, and speed, but it may miss the target. Therefore, it is necessary to determine with great accuracy the direction in which the torpedo should be fire.

In fire at a moving target the tubes are aimed at a point forward of the target ship (fig. 61). If the ship-target and torpedo reach this point at the same moment the torpedo will have struck its mark.

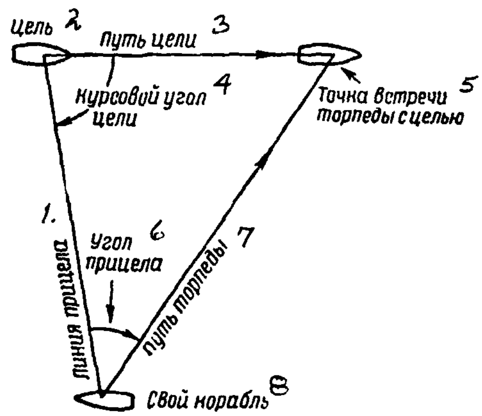

Fig. 61. Diagram of fire upon a moving target (torpedo triangle)

Key: 1. Aiming line; 2. target; 3. track of target; 4. target angle; 5. point of interception; 6. angle of sight; 7. track of torpedo; 8. own ship.

Course and speed of target, values that are necessary for firing a torpedo, are determined visually or by means of torpedo fire control /141 instruments. The first method is simpel but not accurate and can be used only when attacking from short range at a visible target. The second method is more complex but also more accurate.

The torpedo fire control instrument determines the torpedo triangle and determines the lead angle (the angle of sight), i.e. the angle by which it is necessary to deploy the torpedo tube in order that the torpedo and target may meet at the collision point. The computers of this instrument accurately determine the course and speed of the target, calculate the lead angle and gyroscope angle, and transmit these to the torpedo tube.

Torpedo fire control instruments on foreign surface ships are usually installed on the upper deck. They are usually equipped with a turning mechanism which permits uninterrupted tracking of target through a sighting device or, if the target is not visible, to train the instrument by the scale pointers, superposing them on the fixed index.

By way of an instrument for determining the position of a target located beyond the limits of visibility ships usually employ radar which continuously tracks the target and transmits electrical signals about its movement to the movable indicators of the torpedo firing control instrument. By turning the fire control instrument according to indicators the tube operator thereby tracks the invisible target.

It is necessary to introduce certain data into the torpedo fire control device to determine by computer the basic values necessary to conduct fire. For example, the torpedo firing control device carried on American destroyers (fig. 62) receives the following data electrically: the course of own ship from the gyrocompass, the speed of own ship from the log, the relative bearing (the angle between the fore and aft plane of the ship and the direction to the target), and the distance to the target from the radar set. The speed of the torpedo and certain other data necessary for resolving the torpedo triangle are usually introduced into the instrument manually. Consequently, the torpedo firing control device, on receiving the necessary data, solves the rather complex problem of torpedo meeting target and transmits the answers in the form of electric signals which include the lead angle, the gyroscope angle, and spread angle to the instruments on the torpedo launching tube. By turning the launching equipment the tube operator coincides the indicators on the course scale of the torpedo. The launching tube is now directed not at the target proper, but is shifted by the amount of the lead angle.

By matching the pointers of the gyrsocope angle instrument and the spread angle instrument the setter introduces these values into the torpedo. If all computations are performed accurately and the torpedo adheres to the set course and depth during the run it should hit the target.

If the torpedo firing control device has become inoperative it is possible on some torpedo launching tubes to fire using an aiming device which also can determine the torpedo firing data but, naturally, with lesser accuracy.

It is more complicated to resolve torpedo firing problems on a submarine than on a surface vessel. Whereas on a destroyer radar equipment or the sighting device of the torpedo firing control instrument can continuously track the target,in the case of submarines the periscope has to be raised at least for a short time to determine the course and speed of the target. When the periscope is lowered and the range to the target exceeds the operating range of the sonar instruments it is impossible to track the target. In such case the target motion data determined by the commander with raised periscope are introduced manulally into the automatic torpedo firing equipment which, in the course of the attack, resolves the torpedo-target collision problem. If the situation permits, the submarine commander raises the periscope and determines the target -torpedo collision problem with greater accuracy.

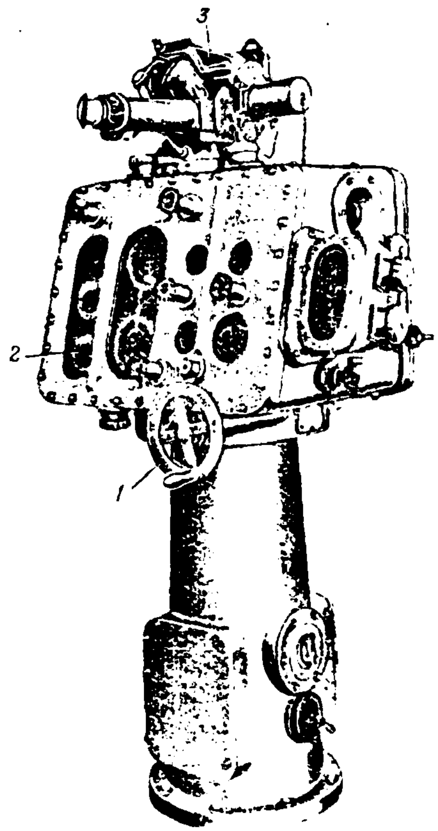

Fig. 62. The Mk-27, a U. S. Torpedo fire control instrument: /142
1. Horizontal laying handwheel; 2. scale; 3. sighting instruments.

Experiences in World War II deomonstrated that in fire upon a target several torpedoes were usually released. Individual torpedo firing is not convenient and this is why. However refined the control instruments may be they cannot determine with absolute accuracy the course and speed of the target -- there is every chance for a small error to creep in. Consequently, the lead angle will also be determined with some degree of error. In addition, when in motion the torpedo itself does not adhere with absolute accuracy to the course and speed assigned to it. These deviations increase as the range of fire to the target increases.

Naturally, it is more convenient to conduct fire at shorter range. In such case it is more difficult for the enemy to evade the torpedo and the target hit probability becomes greater. However, experience during the past war have shown that a torpedo attack delivered at short range was /144
extremely difficult due to the greater fire power of ships and improved means of detection. Night torpedo attacks by surface vessels were usually made from 4,000 meters and during daylight hours the range was usually between 6,000 and 10,000 or more meters. It is obvious that at such great range it is very difficult for a single torpedo to score a hit on a ship. In addition, all calculating data for the attack were made taking into account the speed and course of the target-ship at the moment of fire. However, during the period of run by the torpedo the target-ship could evade the torpedo by changing its own course and speed.

Simultaneous fire by several torpedoes increases hit probability because it offers a chance to overlap a large water area in which the ship may be, allowing for possible errors.

During the war group fire from several ships with the release of a large number of torpedoes was practiced rather often. For example, in the Battle of the Java Sea the Japanese destroyers in seven attacks launched 197 torpedoes, 68 of them released simultaneously during a single action. However, even this great quantity of torpedoes fired from long range were not always successful because of errors in computation and evasive action taken by ships. But this had another effect: the enemy had to maneuver to dodge torpedoes and this permitted the attacking ships either to break away from the enemy or to assume a position more convenient for action.

Salvo fire may be carried out by firing all torpedoes in divergent directions, describing a fan or sector. In such case the course of each torpedo differs from the adjacent torpedo's course by the amount of spread angle a (fig. 63), which is introduced into the torpedo gyroscopic instrument, and the torpedoes cover a greater area, thereby increasing the target hit probability of at least a single torpedo.

In order that torpedoes may not collide with one another in the water they were usually fired at short intervals, the order of fire being from the stern to the bow.

Submarines also very often fire a volley of several torpedoes. For example, three may be fired by the bow tubes, directing one torpedo toward the target ship's bow, the second to the midship section, and the third to the stern. If the torpedo triangle calculations are correct, at least one torpedo should score a hit on the target ship. /146

How is a torpedo attack executed? On picking up a target the surface vessel approaches the enemy within range of torpedo fire. In the process the ship's commander maneuvers his ship, striving to gain a convenient position for firing i.e. a position in which the torpedo-target collision angle may not be too acute or obtuse and the torpedo launching equipment may be in the fire sector.

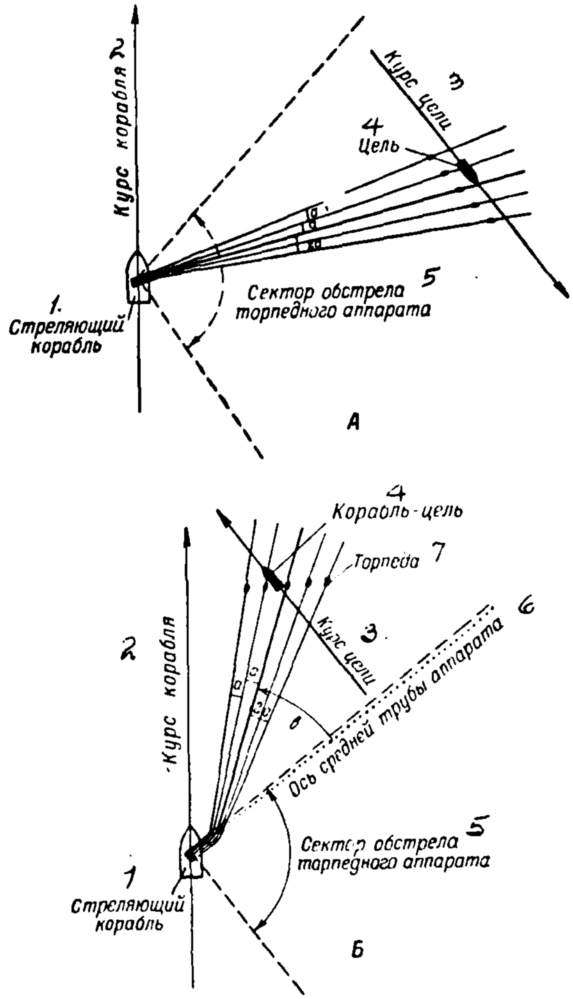

Fig. 63. Torpedo salvo fire:

A. Target in fire sector; B. target outside fire sector --- angular fire with introduction of gyroscope angle; a. spread angle; b. gyroscope angle; 1. firing ship; 2. ship's course; 3. target course; 4. target; 5. torpedo launcher fire sector; 6. axis of central tube of torpedo launcher; 7. torpedo.

angle may not be too acute or obtuse and the torpedo launching equipment may be in the sector of fire.

If the situation does not permit maneuver and the target is outside the fire sector, the commander maeuvers into a torpedo attack, inserting a gyro angle.

The torpedo fire control device continuously develops firing data -- the lead angle and the gyro angle. The tube operator turns the torpedo launcher and matches the torpedo course scale, while the setter inserts the spread angle and the gyro angle into the torpedo. Finally, when the range to the target corresponds to the selected firing conditions a salvo is fired and the torpedoes are released, one after another from the torpedo tube.

Since torpedo tubes in submarines are not movable direction to the torpedo in fire is imparted by the submarine and by the gyro angle. The course to be followed by the torpedo depends on the course followed by the firing submarine and the angle set on the torpedo gyroscope.

With the advent of pattern running torpedoes with automatically programmed control the probability of a torpedo hitting a target increased. If the torpedo does not meet the target at the computed point the maneuvering instrument activates the rudders and causes the torpedo to cut across the target course repeatedly, describing circles, spirals, or zig-zags.

The use of homing torpedoes increased the possibility of the torpedo hitting the target because in fire at long range on practically invisible targets the torpedoes corrected errors made by the commanders.

BATTLING TORPEDOES AND THEIR CARRIERS

The torpedo is a formidable weapon but it can be fought. Is there a way of combatting torpedoes and their carriers? There certainly is!

At first the anti-mine side shielding for ships was developed. With the advent of influence firing mechanisms which struck the bottoms of /147
ships the beam defense proved little effective. Searches were begun for to find protective means against influence firing mechanisms. In foreign fleets, therefore, in order to eliminate the causes of exploding magnetic type influence firing mechanisms of mines or torpedoes, they began to demagnetize ships, i.e. they destroyed their magnetic field. To achieve this effect the ship was girded by numerous bands of cables through which a current was passed with a magnitude and direction such that the magnetic field produced by the cable winding would be equal in magnitude and opposite in direction to the magnetic field of the ship.

Naturally, it is practically impossible to attain a condition wherein the magnetic field of the ship would be completely destroyed (equal to zero), but it appeared possible to reduce the magnetic field to a magnitude at which influence firing mechanisms would be insensitive to it and would not explode. In response to this, firing mechanisms with increased sensitivity were developed which "sensed" and produced an explosion even when the ship had a very slight magnetic field. To be sure, this had its negative side because the influence firing mechanism of the torpedo could explode by passing underneath some small metallic object tossed out by the enemy.

Another version of the struggle with the magnetic influence firing mechanism was used -- the magnetic field of the ship was intensified. The field created by the current flowing through the cable had the same direction as the ship's field and the two fields were additive. They calculated that the magnetic field would be so powerful that the influence firing mechanism of the torpedo would be triggered and the torpedo would explode at some considerable distance away from the ship without causing the vessel any serious damage.

Understandably, these protective devices had great shortcomings and did not insure the necessary protection for the ship against exploding torpedoes with influence firing mechanisms.

Various kinds of protective devices against the torpedo were used. The British produced a special protective device called the Foxer in 1943 when the Germans were using acoustic electric torpedoes that homed in on ship noises, causing many English ships and transports to be destroyed by these torpedoes. This device consisted of two sources of noise towed at some distance from the ship's stern. The noises produced by the Foxer were many times greater than the noise produced by the ship's propellers and the homing torpedoes exploded underneath this device at a considerable distance away from the ship. To be sure, use of this device impeded ship maneuver and interfered with the normal work of the sonar operators. In the battle against the torpedo which was waged at sea the shortcomings peculiar to this weapon were also taken into account. Thus, the range of action of the homing system is comparatively small -- considerably less than the range of torpedo fire; acoustic torpedoes are also slow because the mechanisms of the torpedo produce great noises at increased speed which interfere with the operation of the hydroacoustic equipment. In addition, acoustic torpedoes have a lighter explosive charge than steam-gas and electric torpedoes due to the homing gear being contained in the forward part of the warhead.

The gas-steam torpedo, which has a high rate of speed in water, leaves a visible wake behind it. The engines of gas-steam torpedoes produce a very pronounced hum during operation which can readily be picked up by sonar systems of target ships; this facilitates detection of the torpedoes and taking evasive action against them.

Electric torpedoes do not leave a tell-tale trace and are less noisy, but they are not fast and have a limited range, the most important elements for a successful torpedo attack. As a matter of fact, in the time required by the torpedo to travel to the enemy ship successful evasive action could have been taken.

During the Commander Island operation in March 1943 Japanese cruisers and destroyers fired 49 long range torpedoes against some American cruisers. The torpedoes spent about half an hour in the run toward the enemy ships. During this time the American ships succeeded in changing course several times and not one of the Japanese torpedoes found a target.

Given the greater artillery fire power of the ship a torpedo attack at short range became a virtual impossibility. Increasing the range of run of electric torpedoes would allow submarines to fire a volley from a distance in excess of the operating range of modern sonar detection gear.

It should be mentioned that during World War II the explosion of a single torpedo could not inflict a mortal wound to a modern large sized ship. An average of from 5 to 10 torpedoes were required to sink a battleship, and 4 to 6 torpedoes had to score hits to sink a carrier /149
or a cruiser. Since not all torpedoes fired reach their mark it is obvious that scores of them have to be fired in order to sink a large ship.

For example, over 70 torpedoes were fired at the German battle cruiser Bismarch and only eight found their mark. Therefore, great attention is given to increasing the effectiveness of the explosive charge in the torpedo without further increasing the overall weight.

As the torpedo and its carriers were improved the methods of combatting them also improved. In the initial phases of the past war the British, unable to organize defenses for their own convoys, created an exceptionally favorable situation for the operation of German U-boats. Some German submarines sank over 250,000 tons of Anglo-American merchant shipping. The escort forces protecting the ships were few in number, poorly prepared, and, consequently, could not avert the collosal losses that ensued.

At one period England, for whom overseas supplies of foodstuffs and raw materials were extremely vital, was in a most catastrophic situation. Merchant shipping losses due to German U-boats continued to grow. During the month of March 1942 losses in merchant shipping increased to 500,000 tons, and in the month of June, that same year, they escalated to 700,000 tons.

To protect the convoys from the submarines the allies began to build ships for antisubmarine warfare at an accelerated rate. The main task of ASW ships consisted in the timely detection of submarines and destroying them or forcing them to submerge, thereby preventing them from executing a torpedo attack. For this purpose the ASW ships were equipped with the latest detection equipment -- radar and sonar gear -- as well as means of destruction, such as depth charges and depth charge launching equipment.

Use of ASW ships yielded immediate positive results: allied shipping losses were reduced and the number of German submarines sunk increased. In this case it should not be forgotten that the activization of ASW in the United States and Britain and the expanded replacement of lost merchant shipping were possible only because the main efforts of Hitlerite Germany /150 at that time were directed against the USSR.

The antisubmarine weapons used by the ASW ships consisted of depth charges dropped from the ship's stern and depth charge launchers set up in the forward part of the ship in place of a gun. The American Hedgehog type depth charge launcher was capable of firing a series of 24 depth charges weighing 30 kilograms a distance of 200 meters. Simultaneous fire permitted them to create a danger zone for the submarines. Depth charges of this type carried a small charge which exploded when direct hits were scored on the boat. The drawback of the depth charge launcher lay in its limited range of fire, lack of an influence type firing mechanism, and the low radius of destruction action of one depth charge.

Later on, the Squid type depth charge launcher was developed in England which insured firing a volley of three depth charges. The charge in each such bomb was in excess of 100 kg of powerful explosive ; it was set to explode at a present depth and even if it went off at some distance away from the U-boat it inflicted serious damage. But this launcher was quite cumbersome, not very accurate, and had a limited firing range.

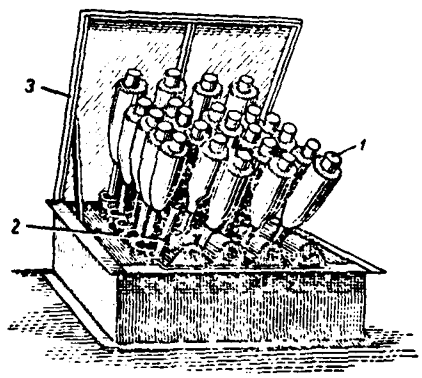

Fig. 64. The Hedgehog depth charge launcher.

1. Rocket propelled depth charge; 2. depth charge arbor; 3. antigas protective shield.

Ships were armed with powerful artillery for beating off torpedo attacks. Antitorpedo nets were set up at the approaches to anchorages. However, events of the past war demonstrated that torpedo bombers, submarines, and torpedo boats could mount powerful torpedo attacks upon ships at sea and in their bases despite all the barriers created.

It should be borne in mind that as the torpedo is perfected the war against it will be conducted more stubbornly and with greater desperation.

TORPEDOES AFTER WORLD WAR II

At the present time torpedoes are under constant development and continued improvement. In order that a torpedo be used effectively it is necessary that it have long range, leave no wake, have high speed, be equipped with a homing system, and carry a charge with tremendous destructive force.

While making intensive preparations for the next war the aggressive circles of the United States and their North Atlantic bloc partners are renewing the arms race. The capitalist countries led by the Americans devote a great amount of attention to the further development of torpedoes. The foreign press carries account about developments of various kinds of new torpedoes.

Thermal type power plants are used to obtain greater speeds and longer runs. The American journal "Missiles and Rockets" carried an account in 1957 to the effect that jet propelled torpedoes developed by the Aerojet Company had an underwater speed of 155 knots (285 km/hr). To be sure, when traveling at such speed the torpedo creates a great deal of noise which can be picked up by the ship-target, but it is assumed that the target will have practically no time to take evasive action. The considerable noises created by the torpedo cause interferences in the acoustic system of the homing equipment. Therefore, systems are being developed which insure the operation of the acoustic instruments at very low frequencies and this would permit adjusting the target seeking system in such a way as to filter out its own noises.

It is felt that the efficiency of the torpedo can be improved by producing influence firing mechanisms against which it would be difficult /152 to take countermeasures. These firing mechanisms should utilize a physical field of the ship which would be extremely difficult to attenuate. Apparently only cosmic rays have such properties. A cosmic firing mechanism for use in mines has been developed in Australia which is triggered when the mine is in the "cosmic shade" produced by a ship.

Having a high capacity of penetration, cosmic rays act upon the firing mechanism at any time of the day. And since it is practically impossible for a ship to escape irradiation by cosmic rays it is likewise impossible to destroy the "shade" which triggers the firing mechanism.

A great project is under way to increase the destructive force of the torpedo. Military specialists abroad feel that the most promising way of increasing the explosive power of the charge is to use nuclear explosives. In striving to realize its intentions, according to press reports, the United States has been engaged during the postwar years in developing a torpedo with an atomic warhead. Using as a basis the 280 mm atomic artillery projectile which weighs 450 kg with a TNT equivalence of 10-15 tons, the Americans feel that the lethal radius of such torpedoes will be increased by 50-70 times compared with conventional charges.

Work is also being done in the area of improved torpedo shell strength which would permit submarines to conduct fire from depths considerably in excess of 100 meters. Foreign specialists attach great importance to this matter because they feel that at a depth of 400-500 meters it is virtually impossible to detect a submarine with sonar equipment.

In the navies of the United States and other countries uninterrupted research is conducted to find ways of improving the accuracy of aiming torpedoes at targets. "Missiles and Rockets", for example, reports that in 1959 the United States was engaged in developing the Mk-39 guided antisubmarine torpedo. During the run this torpedo is controlled by thin wires which are unwound from coils on the torpedo and on the submarine. An operator guides the torpedo from control panels on the submarine. He can check on the motion of the torpedo, direct its run by transmitting command signals, and can trigger the explosive when it is in the vicinity of the target. According to press reports, this torpedo should develop a speed in excess of 50 knots by using super-cavitational propellers.

The American command is devoting much attention to the development of new equipment for the detection and destruction of submarines. Recently, the American Navy developed a variety of small dimensioned torpedoes for use against submarines. For example, in fire from surface ships tests were conducted with the torpedo-missile PAT or, as it is also known, the "Torpedo with Rocket Assist", (fig. 65). The PAT missile has a three stage jet engine and warhead consisting of a small sized target seeking antisubmarine torpedo. The overall length of the missile is 4.2 meters, length of torpedo is 2.4 meters, and the weight is about 200 kg.

The torpedo can carry a conventional explosive or a nuclear charge in its warhead. According to naval specialists the PAT missile can hit submarines at ranges in excess of those of submarine borne torpedoes. The small dimensioned torpedo has high speed and is equipped with a device enabling it to move in spiral fashion at great depth. The PAT torpedo missile is launched from guide rails set up on 127 mm gun turrents; they are aimed by turning these turrets in the required direction.

When the jet engine ceases working the torpedo is separated from the missile; a stabilizing parachute is then deployed and the torpedo continues in free flight. Before the torpedo enters the water the stabilizing parachute is detached and a decelerating parachute is released to reduce the force of impact on the water. As it enters the water the decelerating parachute is detached from the torpedo and the engine is switched on; the torpedo commences to move in spiral fashion in a circular search pattern to locate the target. After picking up the target the homing system controls the movement of the torpedo and guides it to the target. The torpedo follows the target and contacts against it.

The Mg-32 acoustic torpedo (fig. 66) which is released from the deck type torpedo launchers of surface ships is regarded by American navy heads as the chief weapon in its antisubmarine warfare program. In contrast to German torpedoes of World War II with passive search characteristics i.e. when hydrophones were installed in torpedoes for picking up ship propeller noises, American torpedoes additionally carry sonar equipment. This device transmits ultrasonic signals which,on reflection from a submarine, are picked up by the receiver, amplified, and sent as command signals to the torpedo rudder control mechanism.

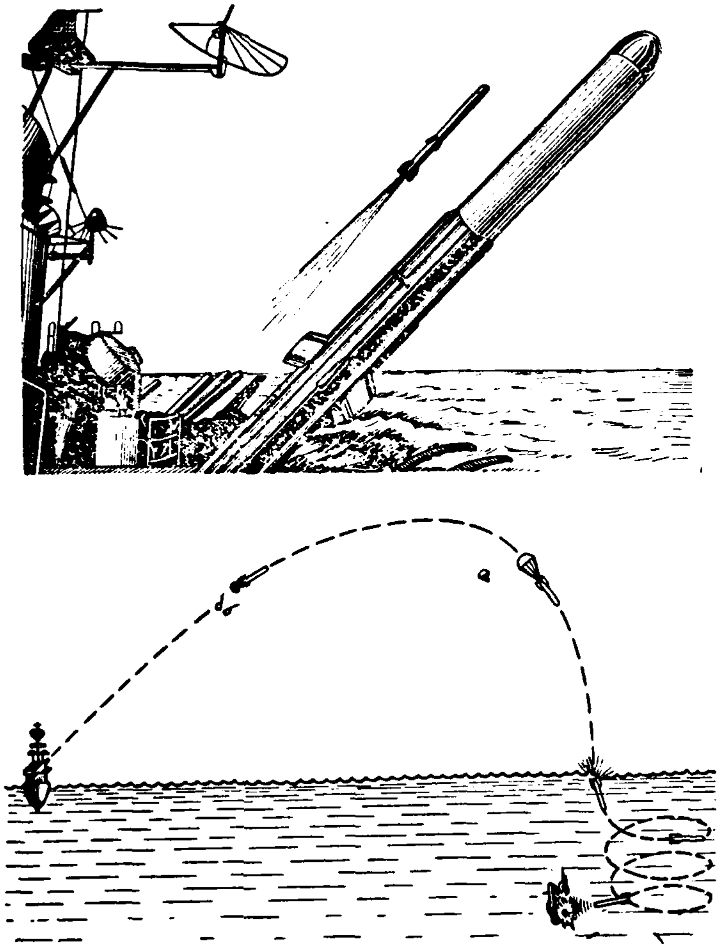

Fig. 65. Firing the jet propelled PAT torpedo missile /154

Instead of piezoelectrical elements, which are sensitive to shock and changes in the ambient temperature, the Americans began using the more dependable magnetostrictive devices in their receivers.

The transceiver is contained in the forward part of the torpedo in a special chamber covered over from the outside with a rubber diaphragm and filled with castor oil for greater sensitivity.

In 1958 the American journal "GeneralElectric Review" reported that the Mk-32 torpedo has some serious drawbacks: when ultrasounds are reflected from the bottom or even from seaweeds the torpedo changes its heading; the noise of the torpedo propellers often reaches such an intensity that the torpedo turns to the sound of its own propellers and "chases its own tail." /156

The the Mk-35 torpedo the Americans propose using silver plates as the electrodes in the storage battery and seawater as the electrolyte. The battery in the torpedo is kept dry and becomes filled with seawater after the projectile is fired. This eliminates any possibility of the torpedo exploding (there is no violent emission of hydrogen) and prevents any splashing of electrolyte. The output of such batteries is five times greater than that of lead batteries and they weigh a tenth as much. However, even those batteries have their shortcomings -- their capacity changes with temperature and the salinity of seawater, and they are very expensive.

Much attention is given in the capitalistic countries, especially the United States, to the matter of reducing the length and weight of homing, deepwater, antisubmarine torpedoes carried in planes and ships. These torpedoes are inexpensive and small in size but the explosion of but one such torpedo can do a great deal of damage to a submarine. For example, according to Naval Aviation News, the American made Mk-43 homing torpedo made of light alloys weighs 113 kg, is 244 cm long, and has a caliber of 25.4 cm (fig. 67).

The American military command assigns a high priority to the development of antisubmarine weapons of underwater vessels, which, according to them, will play an important part in the future. Underwater jet propelled guided missiles are being developed which are supposed to replace antisubmarine torpedoes. The Americans propose to arm the fast ASW atomic submarines with a missile with an underwater speed of from 175 to 230 knots. They feel that the best weapon for reaching a target in the shortest possible time the guided missiles which travel through water in the initial and final portions of their track, while the intermediate portion is in the air.

The United States Navy is developing the Sabrok, a new antisubmarine missile-torpedo of the water-air-water category for used in submarines. In developing this missile the Americans used as a basis a project on which the Germans had been working even before World War II.

The Sabrok missile-torpedo is supposed to be fired from a conventional submarine torpedo tube (fig. 68). /157

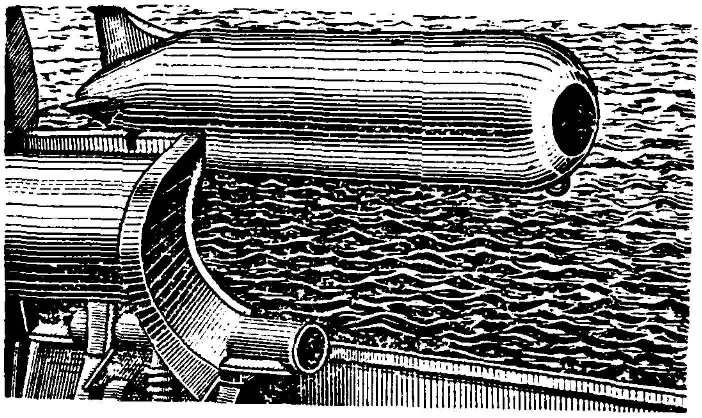

Fig. 66. Firing the Mk-32 torpedo from beam launching equipment.

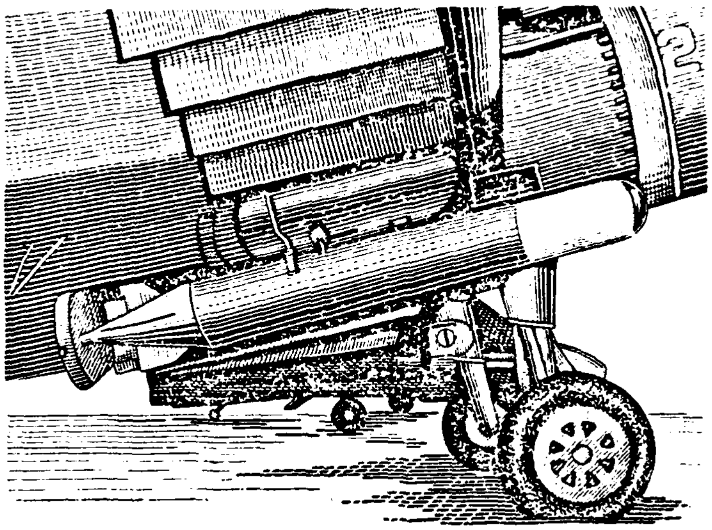

Fig. 67. The aircraft borne Mk-43 torpedo /15/

On emerging from the launcher the missile continues to move under water for a while, following which it emerges from the water and flies toward the target through the air, describing a ballistic curve. In the target area the missile again enters the water and continues moving under the water toward the target.

The ordinary acoustic torpedo is used as the forward part of the missile. To increase the range of the torpedo's underwater run the Americans plan to use a hydroject engine in it whose operating principle is similar to that of an ordinary air jet engine except that water rather than air is used to produce the reactive thrust in the engine. It is assumed that the consumption of fuel in the hydrojet engine will be insignificant. /158 When the missile leaves the water a powerful powder rocket engine is supposed to be switched in.

The warhead of the Sabrok missile can carry a conventional or nuclear charge. It is assume that the missile will have a range of between 45 and 80 km. The Americans feel that the chief advantage of the Sabrok is that it can be fired from ordinary torpedo tubes , hence the absence of any need for developing special launching gear.

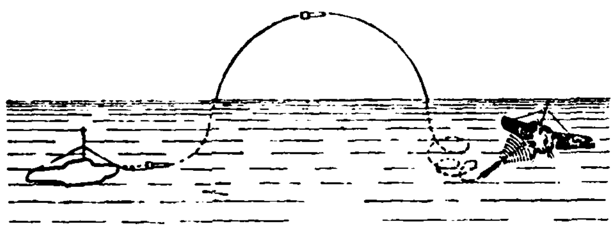

Fig. 68. Approximate trajectory of the American antisubmarine missile-torpedo Sabrok

The Americans are arming not only surface ships and submarines with torpedoes for ASW but aircraft as well. They place particularly high hopes on such a weapon for fighting submarines like the finned aircraft borne missile-torpedo, the Petrel, which is 7.3 meters long, has a 61 cm caliber, and is equipped with four meter long fins.

This missile torpedo is made up of the head and detachable tail portions and is designed for use against submarines and surface ships. The head portion of the missile is the 609 mm long target seeking Mk-13 acoustic Mk-13 torpedo. A turbojet engine which develops a speed of 250 meters/sec for the missile is located in the tail portion which has wings and fins. Also located there are instruments for controlling the flight of the missile (combination system of guidance and homing in the final portion of the air trajectory, a radio altimeter, and other devices).

The target is irradiated by the missile's radar which, on receiving the reflected signals, guides the missile to the target.

The missile is launched from an aircraft or helicopter a distance of 30-40 km from the target. After the missile approaches the target by a distance equal to the range of the torpedo's active homing system the tail portion separates and the torpedo enters the water to begin the search for the target. The contact firing mechanisms will not be triggered on contact with the water; the explosion will take place only when the torpedo hits the target. Missile torpedoes of this type are equipped with devices which react to the acoustic or electromagnetic fields of a submarine. /159

CONCLUSION

The naval fleets of the United States, Great Britain, and other capitalistic countries are engaged in the intensive development of new models of mines and torpedoes. /160

It is interesting to note that the foreign press is striving to explain this arms race as one whose aim is defense against an imaginary "threat from the Soviet submarines." Actually, it is directed toward preparations for aggressive action.

The Communist Party and the Soviet government, which are conducting a peace-loving foreign policy and guiding themselves by Leninist principles of peaceful co-existence with nations having different social systems, are fighting persistently for the preservation and strengthening of peace in the entire world.

Clear evidence of this fact is the proposal introduced by the Soviet government for the consideration of the United Nations of a program for general and complete disarmament and the acceptance in January 1960 at the 4th session of the Supreme Soviet of the USSR of the law for a new drastic reduction of the armed forces of the USSR by 1,200,000 men.

The Soviet Union and the nations of the socialist camp stand for complete disarmament and for the resolution of all controversial problems by peaceful means, by negotiation.

The capitalist nations, whose most aggressive elements are still dreaming of world domination and of new wars, cannot fail to take into account the monolithic force and the will of many millions of peoples.

Our native land has taken great steps forward in the development of industry, agriculture, and a socialist economy. Speaking convincingly of the high level of development of science and engineering in the Soviet Union are such events as the production of a multistage ICBM, the first launches of artificial earth satellites, and an artificial planet in the solar system.Soviet shipbuilders, scientists, and engineers built the first atomic powered surface vessel on our planet.

The launching of the space rocket which planted on the moon a pennant bearing the coat of arms of the USSR, the building of an atomic powered interplanetary stations, and the construction of the atomic icebreaker Lenin -- all these are clear testimony of the superiority of the socialistic system over the capitalistic system.

The Communist Party and the Soviet government, taking stock of the international situation, are persistently engaged in strengthening the defensive capabilities of our nation.

The Soviet armed forces have the most powerful military machine. The Soviet navy is equipped with modern weapons, including atomic weapons and missiles, and is a staunch defender of the Soviet Union's boundaries.

Soviet sailors are capable of delivering crushing retaliatory blows against any aggressor who has dared to encroach upon our great land.

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BIBLIOGRAPHY

I. S. Isakov, Voyenno-Morskoy Flot SSSR v Otechestvennoy Voyne (The Soviet Navy in the Patriotic War), Naval Publishers, 1945.

V. N. Romanovskiy, Flotskiyeminery (Fleet Mine Specialists), Military Publishers, 1956.

G. M. Lebedskov, Torpeda i mina (Torpedo and Mine), Miltary publishers, 1949.

Ya. G. Dorfman, Besedy o magnetizme (Discussions on Magnetism), USSR Academy of Sciences Publication, 1950.

L. Beranek, Akusticheskiyeizmereniya (Acoustic Measurements), Publishers of Foreign Literature, 1952.

V. Borgeze, Desyataya flotiliya MAS (The Tenth Flotilla), Publishers of Foreign Literature, 1957.

A. I. Kisov, Yu. I. Chernov, Morskiye minery (Naval mine specialists), DOSAAF Publication, 1957.

G. M. Novak, B. A. Lapshin, Bor'ba za zhivuchest' korablya (The Campaign for Greater Ship Survivability), Military Publishers, 1956.

Z. Perlya, Rasskazy o boyevykh korablyakh (Accounts of Naval Ships), Military Publishers, 1954.

R. Koul, Podvodnyye vzryvy (Underwater Explosions), Publishers of Foreign Literature, 1950.

A. Travinichev, Mina i sredstva bor'by s neyu (Mines and Methods of Combatting Them), "Morskoy Transport", 1942.

S. I. Rabinovich, Torpeda (The Torpedo), DOSAAF Publishers, 1957.

P. Barzho. Flot v atomnyy vek (The Fleet in the Atomic Age), translated from French, Publishers of Foreign Literature, 1956.

D. McIntyre, Istrebitel' podvodnykh lodok (The Interceptor of Submarines), translated from English, 1956.

T. Rosko, Boyevyye deystviya podvodnykh lodok SShA vo vtoroy mirovoy voyne (Combat Record of American Submarines in WWII),translated from English, Publishers of Foreign Literature, 1957.

Elektricheskaya torpeda (The Electric Torpedo), translated from English, Military Publishers, 1959.

Sborniki referatov po inostrannomu sudostroyeniyu za 1953-1959 gg (Collection of Papers on Shipbuilding Abroad During 1953 - 1959).