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UNDERWATER MINES - PAST, PRESENT AND FUTURE

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ABSTRACT

Some examples of past, present and future mines available in the world are initially covered in this paper. This paper makes an assessment of present day underwater Mines technology for various applications in the area of defensive as well as offensive mining. The capabilities of underwater mines namely, operating as automatic sentinels in deep waters and easy deployment for offensive applications as well, meeting the future needs of naval task forces have also been covered in this paper. Finally the limitations of past and present mines are identified and the solutions to overcome these limitations so as to develop a state of the art mine are suggested towards the end of this paper.

Keywords: Automatic Sentinels, Contact Mines, Influence Mines, Underwater Mine, World War I.

I. INTRODUCTION

A naval mine is a self-contained explosive device placed in water to damage or destroy surface ships or submarines. Unlike depth charges, mines are deposited and left to wait until they are triggered by the approach of, or contact with, an enemy vessel. Naval mines can be used offensively—to hamper enemy shipping movements or lock vessels into a harbour; or defensively—to protect friendly vessels and create "safe" zones.

The Sea Mine which was earlier thought to be a poor nation's weapon has attained a position of prime importance in the armories of many navies of the world. The countries with their newly found freedom imported Sea Mines for building up their armed forces. These imported Mines gradually over the years reached a state of obsolescence. These Mines which required a very large sum of money in their initial outlay are capable of being updated to match the newer threat perceptions and increase their life. Due to various reasons, there is an emergence of a kind of arms race amongst various countries which made the latter to stand on their own feet by avoiding further import of Mines.

These countries over the years gained sufficient knowledge and established required scientific and technological infrastructure to have their own mines with state-of-the-art technology for meeting the present threat perceptions. The technology is incorporated in these mines vary. Mines operating as automatic sentinels in blue water region will have great potential for meeting the future needs of naval task forces.

Various types of sea mines available are shown in fig 1. [1]

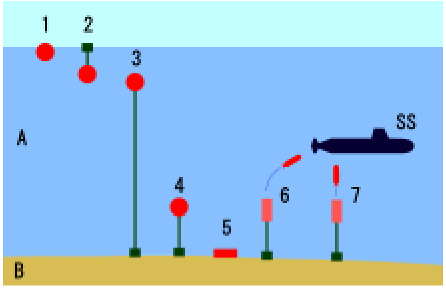

Fig.1. Types of naval mines: A-underwater, B-bottom, SS-submarine. 1-drifting mine, 2-drifting mine, 3-moored mine, 4-moored mine (short wire), 5-bottom mines, 6-torpedo mine/CAPTOR mine, 7-rising mine.

II. PAST MINES

The past Naval mines are mostly different types of contact mines. Some of them are briefly covered in the following sections.

2.1 Contact Mines

Initially, contact mines —requiring a ship physically strike a mine to detonate it—were employed, usually tethered at the end of a cable just below the surface of the water. Contact mines usually blew a hole in ships' hulls. By the beginning of World War II, most nations had developed mines that could be dropped from aircraft and floated on the surface, making it possible to lay them in enemy harbours. The use of dredging and nets was effective against this type of mine, but this consumed valuable time and resources, and required harbours to be closed.

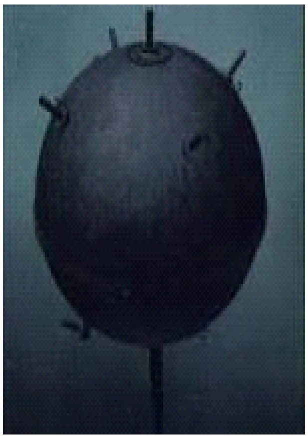

Fig.2. Contact mine:

During the initial period of World War I, the British Navy used contact mines in the English Channel and later in large areas of the North Sea to hinder patrols by German submarines. Later, the American antenna mine was widely used because submarines could be at any depth from the surface to the seabed. This type of mine had a copper wire attached to a buoy that floated above the explosive charge which was weighted to the seabed with a steel cable. If a submarine's steel hull touched the copper wire, the slight voltage change caused by contact between two dissimilar metals was amplified and detonated the explosives.[2]

2.2 Moored Contact Mines

Fig.3. A German contact mine laid in Australian waters during World War II

Generally, this mine type is set to float just below the surface of the water or as deep as five meters. A steel cable connecting the mine to an anchor on the seabed prevents it from drifting away. The explosive and detonating mechanism is contained in a buoyant metal or plastic shell. The depth below the surface at which the mine floats can be set so that only deep draft vessels such as aircraft carriers, battleships or large cargo ships are at risk, saving the mine from being used on a less valuable target. In littoral waters it is important to ensure that the mine does not become visible when the sea level falls at low tide, so the cable length is adjusted to take account of tides. Even during the Second World War, there were mines that could be moored in 300m-deep water (Example: The U.S. Mark 6).

2.3 Drifting Contact Mines

Drifting mines were occasionally used during World War I and World War II. However, they were more feared than effective. Sometimes floating mines break from their moorings and become drifting mines; modern mines are designed to deactivate in this event. After several years at sea, the deactivation mechanism might not function as intended and the mines may remain live. British fleet did not pursue and destroy the outnumbered German High Seas Fleet when it turned away at the Battle of Jutland because he thought they were leading him into a trap: they believed it possible that the Germans were either leaving floating mines in their wake, or were drawing him towards submarines, although neither of these was the case.

2.4 Bottom Contact Mines

A bottom contact mine is the simplest form of mine. It is merely an explosive charge with some form of fuse fitted lying on the seafloor. They have been used against submarines, as submarines sometimes lie on the seafloor to reduce their acoustic signature. They are also used to prevent landing craft from reaching the shore and were a major obstacle during the D-Day landings. The Germans used antitank mines here with minor modifications to make them more reliable underwater, attaching the mines to the front of many of the obstacles seen in photos of the landing.

III. PRESENT DAY MINES

The present day mines are broadly divided into remotely controlled mines, influence mines and moored influence mines.

3.1 Remotely Controlled Mines

Frequently used in combination with coastal artillery and hydrophones, controlled mines (or command detonation mines) can be in place in peacetime, which is a huge advantage in blocking important shipping routes. The mines can usually be turned into "normal" mines with a switch (which prevents the enemy from simply capturing the controlling station and deactivating the mines), detonated on a signal or be allowed to detonate on their own. The earliest ones were developed around 1812. The first remotely controlled mines were moored mines used in the American Civil War, detonated electrically from shore. They were considered superior to contact mines because they did not put friendly shipping at risk.[3]

3.2 Influence Mines

These mines are triggered by the influence of a ship or submarine, rather than direct contact. Such mines incorporate electronic sensors designed to detect the presence of a vessel and detonate when it comes within the blast range of the warhead. The fuses on such mines may incorporate one or more of the following sensors: magnetic, passive acoustic or water pressure displacement caused by the proximity of a vessel.[4]

Fig.4. German parachute-retarded magnetic mine.

Dropped by Luftwaffe bomber during World War II and landed on the ground. Fuse mechanisms are visible Mines can now be programmed to listen for highly specific acoustic signatures (e.g. a gas turbine power plant or cavitation sounds from a particular design of propeller) and ignore all others. The sophistication of modern electronic mine fuses incorporating these digital signal processing capabilities makes it much more difficult to detonate the mine with electronic countermeasures because several sensors working together (e.g. magnetic, passive acoustic and water pressure) allow it to ignore signals which are not recognized as being the unique signature of an intended target vessel.[5]

It is possible to program computerized mines to delay activation for days or weeks after being laid; similarly, they can be programmed to self-destruct or render themselves safe after a preset period of time. Generally, the more sophisticated the mine design, the more likely it is to have some form of anti-handling device fitted in order to hinder clearance by divers or remotely piloted submersibles.[5][6]

3.3. The Moored Influence Mine

The moored mine is the backbone of modern mine systems. They are deployed where water is too deep for bottom mines. They can use several kinds of instruments to detect an enemy, usually a combination of acoustic, magnetic and pressure sensors, or more sophisticated optical shadows or electro potential sensors. These cost many times more than contact mines. Moored mines are effective against most kinds of ships. As they are

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cheaper than other anti-ship weapons they can be deployed in large numbers, making them useful area denial or "channelizing" weapons. Moored mines usually have lifetimes of more than 10 years, and some almost unlimited.[7]

IV. FUTURE MINES - OPERATING AS AUTOMATIC SENTINELS

Some of the countries planning to possess a 'Blue water" Navy, will necessarily have to involve in prolonged operation in deep waters and especially in the continental shelf area. In such depths conventional Mines are not of much use. Hence, in terms of technology it will be an exact opposite of a conventional mine, which is a proximity device.

The Defense Security Service of the United States has defined the blue-water navy as, "a maritime force capable of sustained operation across the deep waters of open oceans. A blue-water navy allows a country to project power far from the home country and usually includes one or more aircraft carriers. Smaller blue-water navies are able to dispatch fewer vessels abroad for shorter periods of time.

These are examples of navies that have been described by various defense experts or academics as being blue-water navies. Some have successfully used their blue-water capabilities to exercise control on the high seas and from there have projected power into other nations' littoral waters.[8][9]. The countries like China, France, India, Russia, United Kingdom, United States etc., have made considerable progress in order to meet the blue water navy requirements.

India initially outlined its intentions of developing blue-water capabilities under the 2007 Maritime Capabilities Perspective Plan, [10][11] with the navy's priority being the projection

of "power in India's area of strategic interest", the Indian Ocean Region.[12][13] Since 2007 the navy has increased its presence in the Persian Gulf and the Horn of Africa to the Strait of Malacca, and routinely conducts anti-piracy operations and partnership building with other navies in the region.[14][15] .The navy operates two carrier task forces centered on INS Vikramaditya and INS Viraat, and also possess an amphibious transport dock, INS Jalashwa.

Fig.5. raft carrier, INS Vikramaditya

V. LIMITATIONS OF PAST MINES AND SUGGESTED SOLUTIONS

Many early mines were fragile and dangerous to handle, as they contained glass containers filled with nitroglycerin or mechanical devices that activated a blast upon tipping. Several mine-laying ships were destroyed when their cargo exploded.

The old Mines gradually over the years reached a state of obsolescence. The technology used in the Mines called for huge batteries with high voltages at many levels and large power at each level which in turn limited the operating life of the Mines. In order to meet growing needs of Mines for various countries, the vintage mines have scope for modification by modernizing the following subsystems.

- Flexural hydrophone as Acoustic sensor in place of vibrator type cantilever mechanism.
- Design control electronics using integrated circuits in place of electronic valves, capacitors and relays.
- Shock protected console to carry the electronics assembly and battery box.
- Lithium batteries to derive low voltages at few levels.

VI. LIMITATIONS OF PRESENT MINES AND SUGGESTED SOLUTIONS

As the Mine-sweeping techniques becoming increasingly intensive day by day, the anti-sweeping measures accompanied with the Mines should be more sophisticated to survive. It is unlikely that a mine laid with a pressure channel selection will be swept with a simulated pressure signature. The past Mines were provided with only acoustic and magnetic channels. Hence they can be swept very easily with the present day technology. Attractive features the present day Mines carry to fight against sweeping are pressure channel, programmable arming delays, target count, inter-target count delays and advanced filters.

The present day Mines therefore necessitate incorporation of following sophisticated technologies and capabilities so that the mine can work perfectly and meet present challenges.

- Shell with composite materials
- Microprocessor based electronics with minimum Hardware
- Software driven
- Intelligent
- Highly reliable
- Excellent localization
- Reliable and compact sensors
- Operate with limited power
- Un-Sweepable
- Long shelf life and operating life
- Good lethal range
- Three influence channels
- Incorporate state-of-the-art technology and concepts
- Classical safeties
- Makes MCM operation more difficult

- Semi-controllable
- Optically and hydro acoustically more and more invisible so as to elude mine hunting.

VII. CONCLUSION

The limitations of Technologies used in the design and development of past as well as present mines are identified and the solutions to meet the requirement of today are briefly introduced. In order to achieve desired results with perfection during war, advanced technologies to be used in the present day mines design are suggested towards the end of the paper. Mention is made about future Mines operating as automatic sentinels in blue waters. Hence the future mines must be designed with suggestions made in this paper.

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