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RUN SILENT RUN DEEP

The Evolution of the Submarine

The submarine came into its own during World War I, its devastating lethality and near-invincibility reinforced during and after World War II, and its nuclear propulsion and teeth giving it virtually limitless range and calamitous destructive power during the post-World War II years. However, it made a fairly late entry into India's naval fleet, possibly because the submarine was earlier considered an 'offensive' weapon platform and hence could not have a place in the arsenal of a country that had pledged to abide by the principles of peace.

Since the capability to operate in the third element - tire subsurface -has now been added to the Indian Navy's repertoire, it is essential that the evolution of the submarine from its tentative conceptual state in the 16th century to its present day status ofbeing the prime dealer of destruction at sea, as well as the significant role it played in shaping the ends of the two World Wars, be studied in detail before apprising oneself of the process of establishment of the submarine arm in the Indian Navy. This chapter provides a brief resume of such developments around the globe.

While addressing the men of the Royal Navy's Submarine Service during World War II, Winston Churchil had said; 'Of all the branches of men in the Forces, there is none that shows more devotion and faces greater perils than the submariner . . . great deeds are done in the air and on the land, nevertheless nothing surpasses your exploits/ Indeed, nothing can transcend the *tour deforce* that the submarine has displayed and the impact of the revolutionary changes in the concept both strategic and tactical, of the war at sea brought about by its invention. Besides, its use for operations against a wide variety of targets during the last century have been far greater than that of the supersession of the oared galley by the sailing galleon, the sailing ship of the line by the steam ironclad, the battleship by the carrier-borne and shore-based maritime aircraft, and the diesel-electric propulsion systems of submarines, by the nuclear power plant. \doption of new techniques, technology, strategy or tactics, weaponry and weapon platforms generally require a fairly long lead time because their potential and advantages over the existing techniques, tactics, etc, have to be convincingly established before they are introduced in any Service. Oared galleys continued to be constructed for England's Navy for several years after the defeat of the Spanish Armada; even thirty years after the first battleship had been fitted with engines, steam ironclads continued to be equipped with sails, and when World War II was coming to an end in 1945, the British Admiralty was still working on a new design fora 16-inch gun turret. For similar reasons, despite the developments in submarine technology in Europe and America concurrently with those in Great Britain, the Royal Navy woke up to the danger posed by submarines only after the outbreak of World War I

when the armoured cruisers, *Cressy, Hoque* and *Aboukir,* were sunk by one small German U-boat as a result of which the Grand Fleet's method of cruising the sea had to be drastically altered. In fact, until the time they learnt their lessons the hard way, the British had been doing their best to discourage the development of submarines because they still believed that they, with their huge surface navy, had nothing to gain and much to lose by their development. As a result of the adoption of this attitude, the design of the first submarine for the Royal Navy had to be purchased from America for construction in Britain and, what is even more surprising, this class of submarines were built not to supplement the British wareffortbutonlyto enable the British designers to find an antidote to them! It is significant to note that until October 1, 1901, when the Royal Navy's Submarine Service came into being with the launching of *SubmarineNo. 1* (120 tons), the popular view in Britain, whichhasa seafaringhistory spanning several millennia, was that submarines were 'underhand, unfair and damned un-English'.

This is of course not surprising as there is no profession so wedded to tradition as the military. During World War I the machine gun hadbeen scornedasthe'much-overratedweapon'; the tank was thought ofasa'toy'; Marshal Joffre had refused to have a telephone installed in his office; poision gas was reluctantly adopted by the British after its use by the Germans was classified as a mere 'accessory'; the trench mortar was projected twice by the British War Office and was finally accepted after a cabinet minister secured the funds for it from an Indian maharaja; British subalterns got their swords sharpened before crossing to France; and as late as 1918 Tershing had cluttered up his supply lines with mountains of fodder for useless horses, still dreaming of Custer and Sheridan and the glint of Virginia moonlight on the shining saddles of Stuart's cavalry.'

Early History

There are occasional references in ancient history to the attempts made by man to seek stealth and surprise by operating from submerged or semi-submerged vessels during wars at sea. The very early protagonists of the submarine were not so much inspired by the desire to descend below the surface of the sea to explore the depths of the sea as to devise a method of rendering a warship invisible to the enemy so that it could carry out surreptitious attacks and escape at will.

The earliest reference to attempts made at waging underwater warfare is found in the writings of Aristotle who recorded that Alexander the Great used diving bells to enablehis men to descend below the surface of the sea during the siege of Tyre in 332 B.C. He also ordered his divers to impede or destroy the defensive barriers (still in use and known as boom defences) the city was likely to build to prevent the movement of submerged vessels. In fact, according to legend, Alexander himself'made a descent into the sea in a device which kept its occupants dry and admitted light.'

However it is believed that nearly a century earlier than Alexander's experiments, the Athenians had used divers to clear the entrance to the Syracuse harbour during its siege from 415 to 413 B.C.

Over the following two millennia the potential and the tactical advantages of operating below the surface of the sea continued to be appreciated by many mlitary thinkers and several attempts were made during this period to develop an underwater platform that could be used against enemy shipping and war vessels far more effectively than surface ships, both for offensive and defensive operations. In the 16th century, during the Renaissance, Leonardo da Vinci, is said to have designed a vessel which could dive, remain submerged for some time and surface unaided and could surreptitiously plant bombs or mines on enemy vessels, but the design of this submarine was kept secret because da Vinci he felt that man would misuse it. 'He knew a method of remaining a long time underwater, but he refused to tell of it because of the "evil nature of man/The Submersible Takes Shap

Experiments in diving and moving underwater continued but the firstrecorded mention of asubmarine design conforming to the basic principles of submersion is found in the writings of a British naval officer, William Bourne,, who published adetaileddesignofa'boatethat may go under the water'in 1578. The vessel was a completely enclosed boat which could be submerged by reducing itsvolumebycontractingthe sides through the use of hand vices, which could bring the boat back to the surface by increasing the volume. This vessel could also move underwater by using watertight oars. This realistic design, provided for both submersibility and propulsion underwater but was never built.

Twenty-seven years later, in 1605, using a design similar to Bourne's, Magnus Fegelius constructed a submersibleboatbut due to the viscosity and adhesive properties of underwater mud the craft never surfaced after diving.

In 1620, a Dutch physician, Cornelius vanDrebel, built a submarine and successfully conducted trials in the Thames river, making the craft cruise repeatedly on the surface, dive, manoeuvre underwater and then surface for several hours at a stretch. He later built two more craft, embodying the same principles, but larger in size. Van Drebel's craft had anouter hull made of greased leatherstretchedovera wooden framework. Propulsion was provided, both on the surface and while submerged, by oars which extended through the sides and which were sealed and rendered watertight with tight-fitting leather flaps which allowed free transverse movement while anchoring the oars to the hull. The underwater endurance of the submarine crew was sought to be enchanced by using compressed oxygen to 'restore to the troubled air such portion of vital parts as would make it again, for a good while, fit for respiration.'After repeated trials in the Thames river had established the capabilities of the new'boate' in travelling on the surface and manoeuvring underwater at depths of 12 to 15 feet, King James I is reported to have taken a trip in one of the larger models to demonstrate its safety. But despite the conclusive proof of the designers having evolved a powerful two-dimension weapon platform, the novel features of the submarine failed toarouse the interest of the British Navy.

The wars in the 17th century in Europe, however, led to a proliferation of submarine designs some of which were the work of men from profess ions other than those associated with the navy or seafaring; in fact some of the designers were men of peace, i.e., priests and monks! One such designer was Oliver Cromwell's brother-in-

law, John Wilkins, Bishop of London. His device for jettisoning gash through an underwater lock while remaining submerged led to the development of underwater lavatories in the latter-day submarines which obviated the need for the submarine to surface repeatedly. He also wrote on future naval developments and centuries latermany of his predictions turned out to be true, such as his predictionof journeys by submarines under the Polar ice-cap, an idea which was dismissed as science fantasy in the 17th century.

By the middle of the 17th century, many naval architects had conceptualized and experimented with possible submersible weapon platforms. In 1653, a Frenchman, deSon, designed and built a 72-foot submarine'that doeth undertake in one day to sink 100 ships' but his submarine never sailed, as its prime mover, a clockwork device, was not powerful enough to propel it on the surface or underwater.

The earlier decades of the 18th century saw numerous 'underwater boats'built, the British designers alone having patented no fewer than fourteen types by 1727. The concept of using a ballast tank for submerging and diving was first visualised by an inventor who described his design in the *Gentleman's Magazine* inl747. Thehull ofhis craft wasequippedwith abankof goatskins which would be filled with water to make the vessel submerge and a'twisting rod'would be used to force the water out of the goatskins which would provide positive buoyancy and bring the" vessel back to the surface. This craft, however, was never built. At this time the mechanical and physical principles involved in diving and surfacing were yet to be fully understood and hence many of the ideas put forward turned out to be impractical, fanciful or, in some cases, even grotesque. Besides the lack of understanding of the principles, the general impression at this time was that it would be impossible to navigate a craft underwater and even if it became possible, its tactical advantages in naval warfare would be minimal.

The First Submarine, Bushnell's Turtle

However, developments of a submersible craft with weapon delivery capability received a shot in the arm in 1776 when the first submarine that could dive, surface, cruise -both on the surface and underwater-and plant explosives on enemy vessels while remaining submerged, made a dramatic appearance during the American War of Independence. David Bush-nell, an American farmer's son, had developed the technique of exploding gunpowder underwater and had followed it up with the invention of the first one-man submersible that was to be used as a weapon platform, the *Turtle.* Shaped like a wooden beer-barrel, it was powered by a hand-operated screw propeller which could move it at a speed of three knots. It could stay submerged for 30 minutes during which it had to approach its target underwater, plant an explosive on its hull and get away.

It was on September 6,1776,29 years before the Battle of Trafalgar, that EzraLee.aseargentin theAmericanRevolutionaryArmyandthe first submariner to launch an underwater operation against enemy vessels, undertook to scuttle *Eagle,* the Flagship of the Britih Fleet which was blockading New York Harbour, by planting a powerful explosive on its hull. He set off on his historic mission all by himself on board the *Turtle* and, operating the handle of the screw-propeller hard for several hours, reached the *Eagle* and dived.

The *Turtle* then got under the hull of the Flagship and Lee tried to bore a screw device into the *Eagle's* hull for securing the explosive device to it. Later, a pre-set clockwork mechanism would trigger the explosive device. Unfortunately for Lee, the wooden hull of the Flagship had a sheathing of copper for reinforcement and prevention of the formation of any marine growth. Despite repeated attempts, Lee failed to penetrate the hull. He persisted with his efforts to plant thedevice, but soon theeffects of carbondioxidepoisoning overwhelmed him. He then withdrew, surfaced and set course for shore but was spotted and pursued by a British patrol-boat. Lee jettisoned the explosive cargo and it went off, almost blowing the patrol-boat out of the water.

The Commander of the British Fleet soon realised that his Flagship had had a narrow escape and ordered the blockading ships of his fleet to withdraw to the outer harbour, where they were comparatively safer, but the effectiveness of the blockade was considerably reduced. Thus while the first sub-surface attack in the history of submarines had proved to be abortive, it brought home one lesson which holds good even today- that the mere presenceofasubmarinelurkingbelow the surface can upset the plans of a tactical commander over a large area far more than the sinking of a ship. In other words, the fear of the unknown and the element of surprise area greaterdeterrentatsea thananactualattack. Submarine warfare thus became a reality, even though the first eversubmarineattackhadfailed to cause any physical damage.

Fulton's Nautilus

Robert Fulton, the American inventor who was the first to propel a boat by steam in 1803, and the first to build a steam warship, the *Fulton,* in 1815, is better remembered for having constructed a three-man submarine boat, the *Nautilus,* in 1795. Incorporating nearly all the main features of a modern submarine and shaped like one, *xheNautilus,* which was built ofsteeland shapedlikean elongated oval, was powered by sails on the surface and by a hand-driven screw-propeller under water. Since the periscope was yet to be invented, a primitive form of a conning tower, equipped with a watertight port hole was provided and was used for observation and manoeuvring the craft underwater. It was also equipped with ballast tanks for diving and surfacing, as modern submarines are, and had a submerged endurance of three hours for four men to breathe and two candles to bum! like the *Turtle,* it had a device which could attach explosives to the hull of ashipwhileremainingunderwater.Duringitstrialsat Brest, the *Nautilus* had also proved its capabilities by sinking an old schooner.

Since the war was over, the American naval authorities showed little interest in Fulton's submarine design, compelling him to build the *Nautilus* at Paris. He offered it to the authorities to deploy it off the French coast against British warships but it failed to sink or damage any

ship.

Disappointed, Fulton then approached the British authorities and demonstrated the capability of his submarine craft by sinking a ship in 1804. The Prime Minister, William Pitt, was so impressed by the submarine's performance that he asked the Admiralty to acquire the craft. His request was,however, dismissed by the

First Sea Lord (then Earl St. Vincent) with the rather intemperate remark, 'Pitt was the greatest fool that ever existed to encourage a mode of war which those who command the sea do not want and, if successful, will deprive them of it.'

For about 60 years after the disappearance of the *Nautilus,* inventors continued to test various designs of small, hand-propelled submersibles with a crew of six to eight men None of these was, however, an improvement on Fulton's craft, and hence no progress towards further development of submersibles was discernible. However, during the AmericanCivil War the next nautical milestone insubmarine development was recorded, with the sinking of a warship by a submarine, when a Federal corvette, the *Housatonic,* which was blockading Charleston harbour, was scuttled by the Confederate submersible *David* (according to the Encylopaedia Britannica, the name of the submersible was *Hanley)* in 1864. An explosive pack, suspended ahead of the bow of the *David* from a bowsprit, accomplished the feat when the submersible rammed the corvette. However, when the *Housatonic* was salvaged, the mangled wreck of the *David* was found sandwiched between the corvette's hull and the seabed. Because of the submersible's proximity to the *Housatonic,* the explosive had proved to beas much of a danger to the attacker as to its target. The *Housatonic* thus had the dubious honour of being the first surface vessel to be sunk by a submarine (and the first surface vessel to have crushed a submarine in an unintended *Kamikaze* attack).

Progress in submarine development continued to be bedevilled by the absence of a suitable propulsion device to enable the submarine to operate underwater for long periods, and an explosive which, ratherthan being planted, could be launched or fired by the submarine from a safe distance.

Steam and Electric Propulsion

Steam engines, though bulky and messy, were tried for some time for the propulsion of submersibles and in 1880, George Garret, an English clergyman, built a submarine which was propelled by two propellers driven by steam from a coal-fired boiler, whichfeatured a retractable smokestack forventilation. About this time, a Swedish gun designer, Nordenfelt, also constructed a submarine powered by steam. This submarine was capable of submerging to a depth of 50 feet, had an underwater endurance of 20 miles and was the first submersible to be fitted with a practical torpedo tube. The novelty of the new weapon-launching device appealed to the Turks and Russians who acquired some of these craft but, because of their limitations, could not achieve anything worthwhile.

Experiments with the still new form of energy, electricity, had in the mean time proved successful, and storage batteries with severalhours of endurance had been developed for the propulsion of submarines with electric motors. In 1886 two Englishmen, Campbell and Ash, developed an all-electric submarine which was powered by two 50-horse-power motors operated from a 100-cell storage battery. It was capable of maintaining a surface speed of six knots but the storage capacity of its battery being very low, its effective range was limited to only 80 miles.

The endurance of the storage battery for submarines was considerably improved by a Frenchman, Claude Gombat who, between 1888 and 1890, built some small battery-powered submarines which were acquired and used by the French Navy for about 10 years. These submarines were about 160 feet long, had a maximum speed of 13.5 knots and an effective range of 200 miles.

The 'Holland Type' Submarine -Ballast Tanks and Hydroplanes

Meanwhile John P. Holland of New Jersey, an ex-Irish school teacher who had migrated to the USA and who was to virtually become the creator of the RoyalNavy's submarineservice,had launched his first submersible in 1875. In 1882 he constructed the *Fenian Ram* which was tested on the Hudson river, and which was propelled by gasoline engines on the surface and electric motors underwater. These submersibles had several features which had to be discarded later, but some of Holland's innovations, perfected during the following years, ha ve been incorporated in the latter-day submarine design- Of these, the most important are the use of ballast tanks for submerging and surfacing, and horizontal rudders or hydroplanes for manoeuvring the craft in the vertical plane for depth control.

For some years Holland and Nordenfelt were vying with eachother for an order from the United States Government for building a submarine and it finally went to the former in 1895. The vessel that was designed, the *Plunger,* was to be powered by a coal-fired steam engine on the surface, and battery-operated twin motors under water. Numerous design ing defects came to light during construction and the craft was eventually abandoned. A new model, Holland's ninth, was built in his shipyard and delivered to the United States Government in 1900 and was used as the basic design for all the submarines that were built subsequently. This submarine, which was launched in 1897 and which was tested for three years before delivery, was named the *Holland.*

A contemporary of Holland, Max Lanbeuf of France, also built a submarine, *Narval,* which was similar in construction to Holland's submarines and it was also powered by a coal-fired steam engine but, instead of tanks, it used the space enclosed in its double hull for ballast.

Internal Combustion Engine

The submarines of Holland and Lanbeuf were the prototypes for submarines built for several decades thereafter and they had almost all the essential features of modern day conventional submarine -ballast tanks, internal combustion engines for surface propulsion at nine knots and for charging batteries whilst on the surface and electric motors for underwater propulsion at seven knots; its effective operational range was an impressive 1,000 miles. However, the internal combustion engines used at that time were gasoline engines which were a fire hazard because they gaveoffhighlynoxiousandinflammablegasolinefumes,and, later were replaced by diesel engines developed by the German engineer, Rudolph Diesel, during the last decade of the 19th century.

Another submarine designer, Simon Lake, had built asubmarine, the *Argonaut Junior,* in 1894 which was primarily meant for use in such peacetime operations as the exploration and exploitation of the living and mineral wealth below the surface of the sea and under the seabed, and for commercial salvage operations. The submersible was made of two layers of yellow pine with a sheet of canvas between them to render it impervious to water. This submarine could moveabout on the seabed and had an air-lock device which permitted its crew, using diving helmets, to emerge from the submarine and explore the surroundings.

In 1897, Lake built his second submarine, the *Argonaut,* which was powered bya 30-horse-power gasoline engine, had a 36-foot cigar-shaped hull and could submerge to the bed of a river or the bottom of a lake and move a long the bed on three wheels which could be retracted and housed in the keel when the submersible was navigated. A year later, i.e$_v$ in November 1898, *the Argonaut had* the honour of being the first submarine to cross the Atlantic when she sailed from Norfolk and, despite heavy storms encountered on the way, reached New York.

Another submarine, the *Protector,* was built by Lake in 1906 and sold to Russia. After it was tested and accepted in Russia, he built several more submersibles for the Russian Government.

The French Submarine - The Gustav Zede

Claude Gombat, a Frenchman, built some small but effective submarines between 1888 and 1890. One of these, the *Gustav Zede,* which was in service with the French Navy for over ten years, had a hull 160 feet long, was powered by storage batteries and had a range of 200 miles at a cruising speed of six knots and a maximum speed of 13.5 knots.

In 1901, this submarine, while taking part in exercises, staged a mock attack on the FrenchMediterranean Fleet after travelling 160 miles under her own power. While remaining totally undetected, the submarine hit the battleship *Charles Martel,* the pride of the French Navy, with a dummy torpedo. The successful'sinking' of a fully protected battleship by **a** tiny submarine which could approach its target, deliver a lethal blow **and** escape without being detected, was a watershed in the history of submarines and was an object lesson to the naval planners of all major countries, in the changes that were going to be wrought into the future shape of sea power.

By the end of the 19th century, only six navies in the world had acquired a total of 10 submarines and eleven more were being built. Leading the submarine-owning countries was France, which had a total of 14, built or building, followed way behind by the United States which had only two, oneof thesetwobeingof theHolland-type which wasatthattime reckoned to be the best design in the world. The other countries which had acquired submarines were Italy, Portugal, Spain and Turkey which had one craft each. Britain, which had one of the mightiest navies at that time, was yet to acquire one because of active and continued discouragement from the British Admiralty.

The 1901 success of the French submarine, *Gustav Zede,* however, came as a rude shock and an eye-opener to the mandarins of the Admiralty, and so it overruled the policy of the First Sea Lord, Earl St, Vincent, and promptly ordered five submarines of the Holland type of the US Navy -not for using them against enemy warships or for coastal defence, but for intensive research into antisubmarine measures! The first submarine built for the Royal Navy, *Submarine No. 1* (with only one torpedo tube) was thus launched on October 2,1901 and the submarine serviceofthe Royal Navy was born.

Submarines for the British Navy –Acute Submarine-Phobia

The policy of active discouragement againstsubmarinedevelopmenthad prevailed in the British Admiralty for about a century. Hence there had been practically no research in submarine development in England during the 19th century. As a consequence the design for the first submarine for the Royal Navy had to be acquired from the USA. In trying to perpetuate this bias, even as this submarine was being commissioned, the Admiralty had decided to curtail the formalities associated with the commissioning of the new vessel to the minimum. To quote an official notice reproduced in the journal *Naval* and *Military Record* of October 3,1901, thedayafter the launching:'It is understood that no ceremony will take place at the forthcoming launch of the first British submarine at Barrow-in-Furness. The Admiralty regard these boats as wholly in the nature of an experiment and, like all other experiments conducted from time to time, this one will be carried out with all privacy.'

Despite the official stance against the development of the underwater craft, shipbuilders in Britainhad actually started building submarines as early as in 1885 - full sixteen years before the construction of the first submarine for the Royal Navy. In that year work had commenced on the construction of an experimental submarine at the Barrow-in-Furness shipyard. This submarine, whichhada 100-foothull, hadbeenbuiltinsections by 1886, sold to the Turkish Government, shipped out to that country, and assembled there for the Turkish Navy. Soon, another submarine, 123 feet long, was built at Barrow and sold to the Imperial Russian Navy. It is interesting to note that 'underhand, unfair and un-English' warfare wasn't acceptable to Britain but others could indulge in it so longas it yielded lucre for her!

After building five Holland-type submarines, Britain built the first A-class submarine (with one torpedo tube) in 1902, B-class (with two torpedo tubes) in 1905, C-class (with two torpedo tubes) in 1906, D-class (with three torpedo tubes, one tube being in the stern, and a 12-pounder gun) in 1908, and E-class (with five torpedo tubes, and one six-pounder or four-inch gun) in 1913. The B-class was the first to be fitted with surface weapons, and the D-class was the first to be equipped with a diesal engine and stem torpedo tube -all earlier classes having used gasoline engines for propulsion, and being fitted with forward torpedo tubes.

The submarine-phobia and surface-vessel mania of the British Admiralty, even after submarines had begun to the built for the Royal Navy, is evident from what Captain Hugh Oliphant, who was the Commanding Officer of *Dolphin,* the Royal Navy's submarine training establishment, and Captain, First Submarine Squadron

some years ago, said about the prevailing ambience at that time: 'One serving British Admiral was at that moment publicly demanding that submarine crews (captured) in war should be treated as pirates and hung; the Director of Naval Construction was warning non-expendable senior officers "never to go below water", and the Engineer-in-Chief considered that the running of a petrol engine in a confined space was so dangerous that the first submarine moorings in Portsmouth were among the remote quarantine and powder hulks.'The first submarine 'depot ship' and training school was thus given the not inappropriate name of *Hazard*[1].

By now, even in the Royal Navy, some of the senior officers had realised the potential of the submarine and were quite vociferous in demanding a change in the naval policy. In 1904, Admiral Lord Jacky Fisher wrote prophetically:

> It is astounding to me, perfectly astounding, how the very best amongst us absolutely fail to realise the vast impending revolution in naval warfare and naval strategy that the submarine will accomplish!'
>
> Here, just to take a simple instance, with the battleship *Empress of India,* engaged in manoeuvres and knowing the proximity of submarines, so self-confident of safety and so oblivious of the possibilities of modem warfare., .and suddenly they see a Whitehead torpedo miss her stem by a few feet!
>
> And how fired? From a submarine of the 'pre-Adamite' period; small, slow, badly fitted, with no periscope at all.
>
> . . . . I have not disguised my opinion in season and out of seasonas to the essential, imperative, immediate, vital pressing, urgent (I can't think of any more adjectives) necessity for more submarines at once, at the very least 25 in addition to those now ordered and building and 100 more as soon as practical, or we shall be caught with our breeches down

The turn of the century was thus a watershed in the history of submarines, for the fundamental principles of the construction and operation of submersibles had taken concrete shape and been demonstrated to the world by this time. It continues to be valid even today. Internal combustion engines, both gasoline and diesel, had proved to be the most efficient and practical power plants; electric propulsion, as an alternative or in tandem with diesel or gasoline engines, had proved a success; the invention of the periscope had increased the feasibility of underwater navigation and improved the potential of the submarine for surveillance and for carrying out attacks while remaining submerged; and the torpedo, theprimary weapon of the submarine, had been perfected and had proved its deadly capability. The manually propelled and operated one-man submersibles had been replaced by the larger and more versatile, long-range and long-endurance submarine. These would soon becomea major component of naval strategy, both for offence and defence. Anew chapter had begun in the history of naval warfare.

Special Features of Submarines Developed

Some ofthefeaturespeculiarto these submarines were the all-welded hull, the periscope, the schnorkel or the snort, the diesel-electric propulsion system and the revolutionary weapon - the torpedo.

Below the superstructure deck was the hull which had to withstand the tremendous pressure of seawa ter while submerged, and to maintain its watertight integrity under varying pressure conditions. The shape of the vessel had evolved from Bushnell's spherical *Turtle* to the cylindrical Holland genre over a period of 125 years, the latterbeing constructed on the basis of the fabrication ofa series of watertight containers by means ' of watertight joints. In the double-hull type of submarines, the pressurehull was inside the outer hull and between these hulls were the water and **fuel** oil tanks,

The space between the non-watertight superstructure deck and the pressure hull was used as locker space for stowing anchor gear, lines, ammunition for the submarine guns, boats and other equipment that did not get damaged by immersion in water. Extending upwards through the superstructure amidships was a watertight tower known as the conning tower, the top of which was the bridge from where the vessel was controlled when on the surface. But when submerged, it was controlled from the conning tower or from a compartment directly below it, known as the control room. For making observations while totally submerged, periscopes extending above the bridge were operated from the conning tower.

Evolution of the Torpedo

The submarine is essentially a torpedo vessel, launching its torpedoes while surfaced or submerged, and hence it has basically evolved over the years as a torpedo-launching platform, though today its weapon outfit includes missiles. The torpedo too has been developed into a highl

complicated underwater projectile with a heavy explosive charge. It is detonated by an exploding mechanism when in contact with, or in proximity to, the hulls of target vessels. Today, high-power engines drive it at high speed and sophisticated instruments control its course. Torpedoes are fired by, or launched by, surface vessels, aircraft or submarines. Its capability of being launched, approaching the target and striking with little or no warning makes it particularly useful to submarines, which can frequently carry out an attack and escape without being detected.

The word torpedo is derived from the word Torpedinidae, the family name for the fish called electric rays. These fish and electric eels, have been referred to as torpedoes. The term torpedo was first applied to an explosive device around 1800 and, in its various experimental forms, this name was used for the next 65 years or so for a type of floating mine.

The first to use an explosive device of this category was David Bush-nell in 1776. His was a simple type of floating mine with a clockwork mechanism which was designed to be secured to the bottom of an enemy vessel with the help of a screw driven into the la tter's hull, and to go off after the pre-set interval. As described earlier, no

damage was caused to the target, the British warship *Eagle,* as the submersible. *Turtle* failed to secure the explosive device to the ship's hull.

Robert Fulton, the American genius whose talents had been recognised not at home but in France and England, used 'a catamaran torpedo' developed by him in an attack on the French Fleet at Boulogne on October 2,1804. Twelve of these devices were turned loose against the French ships, creating great excitement but causing no damage as they exploded short of their intended targets.

During the American Civil War, various kinds of torpedoes were used by the Union and Confedera te forces. Some of these were simple beer kegs filled with gunpowder whose use was responsible for the well-known outburst from Admiral David Farragut, 'Damn the torpedoes... Go ahead!' At the other extreme were the gigantic electric torpedoes carrying over 90 kilogrammes of explosives each, one of which was used to blow the Federal gunboat *Commodore Jones* to smithereens.

It was an English engineer, Robert Whitehead, who, in 1868, perfected the first practical self-propelled torpedo, the forerunner of the modem torpedo. The Whitehead torpedo used all the basic principles that are used even today, such ashydrostaticdepthcontrollateralcontrol, andanengine which powered two contra-rotatingpropellers; the source of power for the 'cold-running' torpedo was compressed air contained in a metal flask which produced a speed of seven knots over a range of 700 yards. During the last decade of the 19th century, the US Navy used this torpedo, its speed increased to27 knots though its range had been extended only by 300 yards.

The first'hot-running'version, the Bliss-Levitt torpedo, was designed by an American, E.W. Bliss, in 1904 and featured a combustion chamber burning alcohol, preheated from the flask in which the pressure was increased. The combination of higher pressure and preheating increased the range to 4,000 yards.

Meanwhile, the introduction of torpedoes had radically changed naval warfare. In 1877, a superior Turkish naval formation was forced to keep clear of the Russians off Odessa because the latter had equipped its ships with torpedoes. With their rapidly increasingspeed, range and hitting power, torpedoes soon became a serious threat to capital ships, i.e., the larger ships of the fleet in later years. Since the torpedoes caused the greatest damage when they hit their targets underwater and since it was impractical to make extensive use of armour for the protection of the 'soft underbellies' of these ships, naval designers modified their hulls by providing double or triple bottoms and highly compartmentalised hulls. Anexcellent example of this is provided by the hull design of the German battleship *Bismarck* which, despite beingrepeatedlyhitbytorpedoesfrom destroyers and aircraft during a lengthy engagement in World War II in May 1941, remained afloat because of her excellent watertight integrity produced by her multi-bottom and multi-compartment design.

About the time of the Spanish-American War, the torpedo-boat came into being and was used to great effect against heavier ships. As a defence against these boats, larger torpedo-boat destroyers were developed, the latter finally evolving into the destroyer whose principal weapon for many years was the torpedo it had originally been designed to counter.

During this period all torpedoes were designed for underwater launching and until 1922 even battleships used torpedoes. A torpedo for being launched above the surface was first developed in 1910; it incorporated a horizontal type turbine instead of the earlier vertical type, had a 'hot-running'engine, a speed of 35 knots and a range of 2,000 yards. Later there was some improvement in torpedo operation but torpedo design virtually remained unchanged until the end of World War I.

During World War I, Germany sank 1,381 Allied merchant ships by using torpedoes alone, and during World War II, German naval designers developed the acoustic torpedo which virtually brought the Allies to the brink of defeat. Itplayed havoc with Allied shipping during the Battle of the Atlantic but the downslide was stopped in the nickof time by developing a device that provided fairly effective defence against the acoustic aspect of these torpedoes.

After the target had been identified and its direction and range established, the acoustic torpedo was launched in the general direction of the target. After traversing some distance, the acoustic device of the torpedo would pick up the noice made by the target's propellers and would" then 'home'on to the source of the noise. This torpedo posed the greatest danger to large convoys as it could be launched in the general direction of the target without having to solve what is known as the fire control problem and leave the rest to the torpedo itself. Another advantage of the acoustic torpedo was that it did not require high speed to intercept its target; so long as its speed was higher than that of the target, it homed on to it though it had to run for a little longer period. This led to the development of the torpedo which could zigzag, popularly referred to as the Wobbly Willie, or follow a spiral track, as did the Curley Charlie, during its course until it picked up the target and homed on to it.

The acoustic torpedo played havoc with Allied shipping during the Battle of the Atlantic. The only defence against this torpedo, was a noisemaker which was developed during the war. Being louder than the target's propellers thenoisemaker diverted the torpedoes to erratic tracks until they lost contact or ran down after exhausting their fuel.

Most of the torpedoes used until the 1950s came in two sizes - those fired by submarines and destroyers were21-inches in diameter and 21 feet long and those fired by torpedo planes and, during the later part of World War II, by patrol-torpedo boats (P.T. boats) were 22.5 inches in diameter and 13.5 feet in length. The cylindrical steel flask containing compressed air at a pressure of3,000 pounds per square inch was fastened to apointed nose-piece containing several kilogrammes of explosives. An exploder mechanism, which was set to detonate when it came into contact with any object, was inserted in the warhead before the torpedo was fired.

During actual operation, in order to prevent discovery by the enemy of an unsuccessful attempt, live torpedoes were designed to sink at the end of their run if they did not explode. Japanese torpedoes were, however, designed to explode at the end of their run if they failed to hit a target. A fewyears earlier, German torpedoes were designed to remain afloat at the end of the run so that they could be used as mines, i.e., there could be some chance of the torpedo being struck by another ship.

The electric torpedo, which was powered by batteries and was cheaper and easier to produce, was slower than the steam torpedo and of less range, but did not produce any air bubbles and hence did not produce any wake. While the steam torpedo had a speed of 45 knots and a range of 4,500 yards which increased to 15,000 yards if the speed was reduced to 30 knots, the electric torpedo had a range of 4,000 yards at 30 knots. Until the early 1950s the mobile platforms used for launching torpedoes included destroyers, submarines, patrol-boats and aircraft. Destroyers and P.T. boats launched torpedoes by ejecting them from tubes mounted on their decks with a charge of powder, the latter also carrying aircraft torpedoes which were merely dropped over the side. These torpedoes were used by the P.T. boats to launch attacks on all types of vessels including battleships.

Torpedoes were launched by submarines from tubes fitted in their bows and sterns with a charge of compressed air. Cruisers were initially fitted with torpedo tubes but discontinued using them after 1936; battle-ships never used them mainly because their gun range far exceeded the torpedo range and at torpedo range they presented very large targets to the
enemy vessels.

The greatest torpedo threat during World War II came from the torpedo planes because the attack could come from a number of directions at once and the warning was very short because of the high speed of the planes. Because of this advantage and better cost effectiveness of torpedo planes over destroyers, World War II saw increasing employment of aerial torpedo attacks.

During World War II submarine warfare was almost exclusively fought with torpedoes; and the effectiveness of the torpedo against surface vessels can be gauged from the fact that out of a total of 10,583,755 tons of Japanese naval and merchant shipping sunk by the Allied forces during World War II, 5,320, 094 tons, i.e., over 50 per cent was accounted for by torpedoes fired from United States' submarines alone.

Other Important Features

As is well-known, the eye of the submarine is the periscope which was invented and developed solely for the purpose of providing a means to view the surface or sky without detection by surface vessels or aircraft. The earlier designers of submarines didn't provide for any viewing device for submarines when they were in a submerged or semi-submerged state, as a result of which they had to grope their way blindly after diving. But the need for a suitable viewing device was soon realised and in 1854 a Frenchman, E.M. Marie-Davy, designed a submarine sight tube containing two mirrors, one above the other, held at the angle of 45 degree and facing in opposite directions. These did provide some degree of sight to the submerged vessels but were rather limited in performance and were hence substituted in 1872 with prisms. The credit for inventing the original periscope goes to Thomas H. Doughty, who developed the basic form during the American Civil War.

The first American submarine to use an internal combustion engine was fitted with 45 horse-power, two-cylinder, four-stroke gasoline engines while the British preferred gasoline engines fitted with 12 or 16 cylinders.

The inherent hazards of these engines were soon realised, for stowage was a constant problem and handling of, fuel was extremely dangerous. Also, internal explosions were frequent and manyof the engines gave off considerable carbon monoxide fumes, creating a menace to personnel.

M.A.N.(MaschinenfabrikAugsberg-NwinbergA.G.) of Germany had developed a four-stroke diesel engine, capable of producing 1,000 horse power but all these engines developed structural weaknesses in the crankcase. Until 1930 the engines used in most submarines of all the larger naval powers with the exception of Great Britain were four-stroke diesels.

With the development, however, of fleet type submarines, the need formorepowerful engines became apparent and eventually a 16-cylinder single-acting engine was developed as well as a 9-cylinder double-acting engine. The fact that submarines are both surface and sub-surface vessels placesdefiniterestrictionsonsize,hull design and shape. The total weight of the submarine is also a factor having considerable bearing on underwater operations. In the first engine-powered submarine, the engines were mechanically connected directly to the propeller shafting. It, however, became apparent after testing various types and designs, that the diesel-electric drive was the best. In this type, the engines were connected onlyto the generators, which in turn supplied power to the main motors drivingthe propeller shafting. Another function of the generators was charging the storage batteries.

Today's fleet type submarines are generally powered by four main propulsion diesel engines, each capable of driving a generator producing around 2,000 horse-power which in turn drives a slow-speed motor or charges a bank of batteries. Anauxiliary engine is also available for driving the generators.

As is known, the conventional submarine does not use the diesels or generators while submerged, and power for the motors is supplied by two sets of storage batteries, which are charged by the auxiliary and main generators during surface operations. The two main storage batteries consist of two groups of over 100 cells each, each one of these cells weighing several quintals.

During the latterpartofWorldWar II, the Germans adopted a radical change in submarine design known as the 'schnorkel' - an invention made by the Dutch in 1936 for replenishing air supply of the crew of their submarines. The spelling was simplified by the Americans to'snorkel' and further abbreviated by the British to 'snort'. The Germans were forced to develop the new device because of the rapid strides already made in the development of improved sonar (underwater sound-aided detecting and ranging equipment) and radar, used by the Allied aircraft and surface vessels against German vessels.

The schnorkel wasoriginallyabreathingtube which was raised while the submarine was atperiscope depth. Whenitwas raised in position, air for the crew was obtained from the surface. In 1944 the Germans equipped their submarines with double-tube schnorkels, one for letting in air for the submarine's diesel engines and crew and the other as an exhaust for diesel fumes, carbon dioxide and other pollutants. The intake tube projected by a foot or so above the sea surface while the exhaust gases were discharged into thesea.This considerably reduced the visible portion of the submarines and also consumption of electric power, since the submarine could cruise almost totally submerged on its engines and conserve its battery power for attacks and evasive measures.

The schnorkel had only one drawback. While by itself it was too small to be spotted from a distance or from the air it left a distinct wake which could be visually picked up from an antisubmarine ship or aircraft in calm weather. It could also be detected by the radar fitted on ships or aircraft. Darkness or fog could not provide any camouflage any more.

The United States Navy developed an improved schnorkel and also the 'guppy' submarine at the end of World War II. The guppy (greater underwater propulsion power) had the same type of hull as that used for the fleet submarine of Wor ld War II fame, was 306 feet long and displaced about 1,800 tons. The only change in the hull was in the superstructure which was radically changed by reducing the surface and streamlining every protruding object. The life lines and all guns were removed, the bitts (posts) to which ropes were secured were made retractable and the .periscope shears (supports) enclosed in a streamlined metal fairing. All topside armament and equipment were either removed or made retractable and streamlined. The speed of the new 'guppy' was considerably greater than that of the fleet-type craft, and nearly twice that of the old-style submarines. Great changes were broughtabout in submarine construction by the lessons of World War II. Torpedoes came to be fired by hydraulic pressure instead of compressed air as was done previously, eliminating any chance oftell-taleairbubbles escaping to the surface and betraying the submarine's presence.

Hulls also underwent a major change - they were given greater strength for deeper diving that enabled the submarine to di ve to greater depths than was previously possible. Hydraulic mechanisms (oil) were employed extensively throughout the ship for quiet, efficient operation. Radar and sonar equipment increased in importance as it increased in efficiency. Torpedoes no longer had to be fired with sharpshooting accuracy; fire-control equipment and homing torpedoes (the torpedo that seeks its target) eliminated much of the guesswork and chance in firing torpedoes, engines, electric motors and generators were mad e more compact.

The exploitation of atomic power soon became a practical reality to be used for the first time in a submarine propulsion plant. Nuclear power was specified to generate steam within the hulls ofthe US submarines *Nautilus* and *Seawolf.*

A radical change was brought about with the introduction of nuclear power but its application to ships was conventional in that steam and turbines had been used in ships, but unconventional in that it was the first

time that US, submarines had used steam since the very first unsuccessful submarine in 1895, and that this was the first time nuclear energy was used to drivesteam-turbine genera tors which in turn drove the propulsion motors andshafttowhich the screws were fixed. This means of propulsion along with greater speed also gave the submarine anadvantage of almost unlimited cruising range and submerged endurance, a limit probably restricted only by the endurance of its crew and its storage capacity.

The Emergence of the Submarine During World War I

When the First World War broke out in 1914, not many people were convinced of the threat posed by submarines to surface ships until the British cruisers *Cressy, Hogue* and *Aboukir* were torpedoed by the German U-boat U-9off the Belgian coast withaloss of 1,200 lives. This made it clear that the submarine was going to become a potent weapon in future naval warfare and, what was of immediate significance, that many British harbours laywell within the operational range of German submarines. At the recognised war base for the Grand Fleet in the Orkney Isles at Scapa Flow, boom defences for British harbours were practically non-existent. On September l,1914/afalse alarm of anenemy submarine in the Flow caused this anchorage to be abandoned by the fleet in favour of Loch Ewe on the west coast of Scotland until submarine defences could be hurriedly improved and the Loch rendered safe for navigation.

British submarines were than employed on patrol off the Heligoland bight and the narrow waters round the coast on the look-out for enemy men-of-war. Soon U-boats were busyattacking the troop transports going to France. Tomeet this attack the Dover patrol, consisting of destroyers and small craft backed up with extensive mine-fields, was deployed and proved to be quite successful in keeping the U-boats at bay.

As the War progressed, the range and efficiency of the submarine increased rapidly and British boats were employed effectively in waters such as the Baltic and Marmara, which were denied to British and Allied shipping by mine-fields.

The U-boat achieved considerable success up to the end of 1914 but it had little effect on the naval situation. However the sinking of six merchant ships on January 30, 1915, gave an indication of what was to come. On February 2, in reply to the British declaration of blockade ofthe enemy coasts, Germany published a notice warning all peaceful shipping against approaching the coasts of Britain, followed by a memorandum on February 4 proclaiming that after February 18, the waters around Great Britain would be considered a military area, that every hostile merchant ship found there would be sunk without regard to safety of passengers or crew and that even neutral ships would be in clanger. This was promulgated and enforced despite the illegality of this measure being pointed out by the USA.

The state insurance scheme in Great Britain prevented panic as regards antisubmarine measures adopted and the Order in Council of March 11, known at that time as the Retaliatory Order, was issued. Merchant ships were advised on the precautions to take, the best procedure to adoptwhen attacked and on the use of wireless telegraphy. Minefields were laid to protect shipping routes in the North Sea, the auxiliary patrol was

strengthened and various navigational measures were adopted. In spite of all precautions, however, losses continued and the range of attack increased. Many victims were claimed by the German mine-laying submarines, which laid their mines near the approaches to harbours close to navigational light vessels and bouys; these mines claimed victims of all nationalities on the British East and South Coast routes. After April 10, the bigger U-boats operated only in the North Sea and Western approaches where their worst victim was Scandinavian shipping. In May 1915, the *Falaba* and *Lusitania,* two passenger ships, were sunk, with ht. vy lossoflife. It caused widespread indignations and following US protests, the German government issued instructions to its U-boats to spare large passenger ships. A further American protest on the occasion of the sinking of the White Star liner *Arabic* called forth fresh instructions from Germany, and the first U-boat submarine campaign in British waters ended in September 1915. By June 1915 U-boats had entered the Mediterranean and, working from Austrian Adriatic ports, became a serious threat to the Dardanelles and Salonika expeditionary forces, prowling the sea areas.

During the months of transition from 1915 to 1916, the Germans increased the U-boat fleet and decided to sink defensively-armed merchant ships without warning, though passenger ships were still to be spared. The sinking of the *Sussex* crowded with passengers brought further strong protests from the US President and again Germany gave way. The Allied blockade affected US commercial interests so adversely that feelings against England grew bitter and tension between the US and Germany diminished. Encouraged by this, Germany decided to renew its war on commerce, and now Scandinavian shipping became its main target. The sinkings rose so fast that Admiral Sir John (later Earl) Jellicoe took the unusual step of writing to the British Prime Minister directly, calling his **attention** to the fact that the loss of shipping alone might soon force the Allies to seek peace. He was in consequence appointed First Sea Lord so thathecoulddevotehimselfto finding theanswer to this problem. Tension between the US and Germany again increased because of the depredations of a U-boat off Nantucket. During December 1916,167 Allied and neutral ships were sunk and in January 1917, the loss rose to 180. Germany resumed unrestricted warfare and, on February 1, 1917, it declared the areas enclosing Britain, France and the Mediterranean to be war zones, adding later the Portuguese Atla ntic isles and Archangel. It decided to destroy vessels of any nationality or character found in the war zones without consideration for their passengers, crew or mission.

Despite all possible antisubmarine measures, the Allied losses continued to mount rapidly andit appeared thatthe U-boats would win the war. They were being built faster than they were being destroyed and it was clear that the existing methods of dealing with them were inadequate. On April 19, 1917, the worst day of the worst month for Gr eat Britain, 11 merchantmen and 8 fishing vessels were sunk. Oneoutof every fourvessels that left the British isles that month never returned. This unrestricted war on commerce brought the United States into the fray and by the end of the year, it sent 37 destroyers to assist the surface forces of the Allies.

Meanwhile, a new form of defence against U-boats became imperative and the convoy system, which had been used in the old French wars, was resorted to. This method, first employed on the short voyages to France, and Scandinavia, and later on other routes proved to be quite successful and by November, the shipping losses were reduced to less thanhalf of what they hadbeen inMay. However, scientists and inventors continued to work on a suitable antisubmarine device and the first success came with the invention of the hydrophone. On April 23, 1916, the trawler *Cherio* located the German submarine *U.C.3* with a hydrophone, sinking it, with depth charges within minutes of detecting and locating it.

As the end of 1917 approached, it became increasingly clear that the submarine attack on commerce had been countered. The U-boats failed tq check, either the movement of British troops to France or of US troops to Eu^*pe, and by October 1918, the building of new ships had overtaken the sinkings. Shore-based aircraft and dirigible balloons were used effectively for spotting U-boats and for some time the latter found the Straits of Dover too dangerous for use; soon they had to abandon the Flanders bases and as the Allies advanced, the Germans had to destroy the U-boats. At the Armistice, 138 U-boats that had surrendered were brought to Harwich. While the war was over and Germany had accepted defeat; **it** had clearly established the fact that the submarine was decidedly the deadliest weapon platform at sea.

The tremendous success of German submarines during World War I is apparent from the devastatingly high number of naval vessels and merchant ships sunk by them,. though they themselves had to pay heavily for their remarkable achievements. The number of Alliedmeichant ships sunk rose alarmingly from 568 in 1914-15 to 1,098 in 1916 and then to2,639inl917but fell to 1,103 during the first ten months of 1918 mainly due to the introduction of the convoy system, deployment of submarine chasers and the introduction of underwater listening devices for the detect tion of submerged submarines. The German U-boats also sank 10 battle ships, 18 cruisers, 13 destroyers, 13 submarines and40naval vessels of other types. Although the U-boat losses suffered by the Germans also steadily rose from 24 in 1914-15 to 25 in 1916,66 in 1917 and 68 in 1918 in the final analysis, the Germans lost only 183 U-boats during the entire War but accounted for 5,408 merchant ships and 94 naval vessels.

At the end of World War I, the British realised that the Allied victory was a 'very close-run thing'and their greatly superior battle fleet on which sea power had depended for several centuries, had not been able to do much to counter the threat from below the surface. The submarine had not been able to defeat a battle fleet but by adopting the tactic of attacking commerce directly, it had become a potentially war-winning weapon.' Secondly, the British had found the submarine of great value because it could operate in areas where ships could not go such as in the Baltic and the Sea of Marmara beyond the Dardanelles. Thirdly, submarines had also proved useful for reconnaissance and by the end of the war, the Grand Fleet itself included fast steam

submarines of the K class. And finally, the submarine had shown itself to be quite effective against its own kind and British submarines had sunk 18 U-boats.

Despite this realisation, the British decided to press internationally for the abolition of the submarine. In 1922, the British efforts to do so at the Washington Naval Limitation Conference were opposed by all the other countries and did not even secure agreement to limit submarine numbers. The Conference could only come to the decision that the remaining U-boats should be destroyed and that the Treaty of Versailles should ensure that there were no U-boats in the post-war German Navy.

At the London Naval Conferene of 1930, the British once again made a bid to abolish the submarine and failed. But they did succeed in getting an assurance that they would never be used for commerce raiding.

Submarine Development during the Inter-War Years

Although the British felt that submarines were 'underhand, unfair and damned un-English', Britain continued to build submarines after the war. Between 1918 and 1920, four super submarines of the M class of 1650 tons each (Ml to M4) were built. These had 12-inch guns for bombardment for inland.But these submarines were oddities -besidesmassive guns, one hadprotrudingfunnelsandonewas equipped with anaircraft and hangar! There was the K class submarine with protruding funnels, In 1925 a new type of submarine, called the X-1 class, with four 5.2-inch guns in twin turrets and six forward torpedo tubes, and displacing 3,050 tons was built. During the inter-war years, the development of the ASDIC gave the Britishsomethingthey hadneverhadbefore,andthoughits range wasshort it could make depth charge attacks on U-boats much more accurately.

The submarine continued to develop into a potent weapon platform withher greatest asset being concealment: the ability to move unseen and undetected in thedepthsof the ocean. Theaccentat that time was on using its submersible capacity mainly to transit secretly underwater and improve the efficiency of its weapon system for use whilst afloat.

Other nations continued to build larger submarines. In 1934 the French built the *Siircoufoi* 2,880 tons mounting 8-inch guns, and during the late 1920s the Americans built the *Narwhal* and *Nautilus* of 2,730 tons and the slightly bigger ^r^onawf, each equipped with two six-inch'guns.

The interveningyears between the two Wars did notsee muchchange in the essential features and capabilities of submarines. Most of the oceangoing submarines were between two and three hundred feet in length and their diesel-electric power plants could propel them at average speeds of 20 knots on the surface and ten knots whilesubmerged.Forunderwater propulsion, endurance at 10 knots was less than an hour while at three knots it rose remarkably to two days.

The Submarine's Devastating Role During World War II

During the opening stages of World War II in 1939, conditions at Scapa Flow bore an unfortunate resemblance to the conditions in 1914. In 1914 there were no nets, only a few old guns; in 1939 there was only a single line of antisubmarine nets, a few blockships (ships used to block channels, etc.) and eight anti-aircraft guns. On both occasions the fleet had to evacuate the base temporarily and move to Loch Ewe, a great disadvantage entailing many extra hours of avoidable steaming to the focal points for deployment in the North Sea and to the Shetland-Norway passage. A falsealarmofasubmarineintheFIowhadbeen the cause of the 1914 evacuation; the 1939 one was occasioned by the sinking of *Royal Oak* by a German submarine and the bombing of *Iron Duke* which soon followed.

By August 1939, Germany had 60 U-boats ready for action as against her planned strength of 300. The British fleet and coastal command was prepared, but conditions were less favourable to Great Britain in some important respects than they were in 1914. At the very beginning Eire had declared its neutrality and Britain was deprived of three valuable bases -Queenstown, Berehaven and Lough Swilly. It was also obvious that Italy was going to join Germany, and after the fall of France and Norway the entire coast of Europe from the North Cape to the Spanish frontier was hostile. This entailed Britain's abandonment of the South western approaches to the EnglishChannelbecauseof thethreatfromtheair,amuch longer sea passage round the North of Ireland and heavy additional convoy commitments for the North Sea and Scotland.

Between the two Wars there had been little change in the size and shapeof the German U-boats but theyhadimprovedinspeedandwere able to remain submerged for longer periods without surfacing, this capability improving further in 1944 when they were equipped with the schnorkel. They could dive far deeper than before, which had not at first been realised by the British, and they were armed with electric torpedoes which had no tell-tale discharge bubbles and left no track. Great progress had been made by both sides in improving aviation and the means of communication, and the institution of the British Coastal Command for close and active co-operation with the Fleet was to pay rich dividends. The bomber command also played an important part, both at sea and in land
warfare.

The British submarines and the aircraft of the coastal command were assigned the important duty of carrying out the close blockade of Germany's coasts and harbours-a task which was England's traditional weapon against continental enemies in all its European wars. This proved an arduous, perilous and most monotonous duty, which extended over **a** constantly increasing area as Germany continued to expand the area under its dominat From the very outset, unrestricted warfare was waged by Germany and the British convoy system was in operation from the middle of September 1939 as far as the supply of escort vessels would permit. At the beginning the U-boat attack was concentrated on the focal areas and was countered by surface patrols assisted by spotting aircraft from aircraft carriers, but after the sinking of *Courageous,* this practice was

abandoned. The British occupation of Iceland and the Faeroe Islands in 1940 forestalled their capture by Germany and provided new bases for escort and air operations.

Great Britain had by now invented the ASDIC (the submarine detec-tiondevicedevelopedby the Allied Submarine Devices Investigation Committee), the modem version of it being called sonar, agreat improvement on the hydrophone as, besides detection, it gave the direction of the U-boat accurately. Radar had been invented butwas notfitted intheAtlantic escort vessels till 1941 and HF/DF (high-frequency direction-finding apparatus) was introduced in 1942.

President Roosevelt and Prime Minister Winston Churchill had, in order to counter a possible combined German-Japanese attack, agreed on Plan Rainbow prepared by their Chiefs of Staff for joint action, if necessary, as early as 1940. Under this plan, the defeat of Germany was regarded as the first objective and that of Japan as the second. Consequent on the Japanese attack onPearl Harbour on December7,1941, acombined Chiefs of Staff Committee was formed with headquarters in Washington. Great Britain undertook the responsibility for the East Atlantic, Mediterranean and Indian Oceans, and the US with the assistance of Australia and, New Zealand undertook that for the V.est Atlantic and the Pacific.

At the beginning of World War II, as in 1914, Great Britain was very shortof escort vessels, butimmediatesteps were taken to mass-produce the necessary small craft. The German tactic was to attack convoys at periscope depth with torpedoes by day, or single ships with gunfire by night. Magnetic mines were also Jaid in large quantities, causing many casualties, until the discovery of the simple antidote of degaussing ships, i.e., demagnetising the hulls with encircling current-carrying conductors. Around the middle of 1940, Germany withdrew its U-boats for use in the Norwegian campaign, thus affording temporary relief to the convoys, but the overrunning of France and Norway by Germany provided the latter with a number of new bases. Britain had to abandon the use of the south-western approaches, and the German occupation of Norway brought the focal point ofBritish commerce much closer to the operating range of the U-boats and thus rendered their tasks much easier. In March 1941 there was a noticeable change in U-boat tactics. Because of their superior speed, they found they couldattackonthesurface at night. But Britain was fitting radar in the escort vessels and in that very monthitmade its first kill. However fearofinvasionnecessitated diversion of convoy escorts to other tasks and this caused the toll of shipping losses to rise considerably, especially as the production of U-boats exceeded sinkings. However, Britain increased the Coastal Command, and new aircraft of greater range enabled the air patrols in focal areas to drive the enemy into the open ocean. Germany also produced a better aircraft, the Focke-Wulf, but, because of the lack of co-operation between its navy and air force,the results were less satisfactory. Though they were attacking as far west as longitude 40 degree, Great Britain now had new air bases in Iceland and Newfoundland and could provide escorts for food and *material* convoys.

In order to maintain the pressure, Germany had to devise some new tactics. The new tactic that was devised was to attack a convoy with a number of U-boats over a short period of time so that if some boats were discovered and counter attacked by the escorts, other U-boats could get closer to the convoy and attack it unmolested. In other words, they shadowed the convoy and, with their superior speed, were able to concentrate on it and swamp the escorts. These pack attacks during 1941-1943 were made at night. To deal with them, the escorts were provided with what were known as escort carriers, i.e., small aircraft carriers whose planes could search out the surrounding waters by daylight. Escort teams were given intensive training and instructions and they were kept together in units as far as possible; but the sinkings, instead of decreasing, continued to increase.

DespitePlanKainbow,theUSwasunpreparedfor submarine warfare when Pearl Harbour wasattacked. Italsohadnoconvoyorganisation and lacked escort and aircraft. In January 1942 Germany had 20 U-boats operating in the US coastal waters, causing very heavy losses. But by May the US had coastal convoys in operation and inconsequence the hunting ground for the U-boats shifted to the Caribbean area.

For some time the coastal convoys had an easier task but theRussian and Malta convoys suffered severely. TheRussianconvoyroutehadtobe closed for a time, but not before an alternative supply route had been completed by rail through Iran. After the fall of France, with the exception of Spain, both sides of the Mediterranean from Gibraltar to Egypt and Turkey were in the hands of the Axis powers. Convoys from Malta to Alexandria had to pass through the narrow waters between Sicily and Tunis, 'Bomb Alley' as it was called, where they were exposed to intensive attack from submarines and aircraft. Since May 1940 the Mediterranean had been closed as the supply route to the East as a result of which British shipping, not only for India but also for the Far East, had to be sent round the Cape of Good Hope, which added 12,000 miles to the route and weeks of extra steaming.

Only at great hazard did the Allied convoys find it possible to get through to Malta. Nevertheless, the Allied submarines based at Malta played a decisive role in the North African campaign, preying on the Axis convoys supplying the North African armies. Up to the time of the advance of the 8th Army from El Alamein, they and the air and surface craft based on Malta together sank 300,000 tons of German shipping. The vital part Malta played in the Mediterranean operations was realised by Germany, and an intensive attack inMarch 1942 was intended to neutralise the island but vital convoys got through and, in spite of heavy losses, they and the 'magic carpet' kept the island supplied. The magic carpet was a submarine ferry service which transported large quantities of essential gasoline andstoresofall kinds from Egypt. The German forces could have overrunEgypt but for the heavy losses ofmen and supplies caused by the forces operating from Malta.

The whole of the East Coast of North America was now Allied territory but there was a largearea of the North Atlantic which could not be patrolled by the coastal forces acting from Britain, Iceland and North America. This area, known as the'gap'or'black pit', had to be crossed by the convoys. When Germany decided thatit was advisable to avoid the coastal forces on both sides of the Atlantic, U-boat attack, orga "used and controlled from its Headquarters in France, was concentrated in this area. The plan was to employ packs of

up to 25 U-boats and send them independently to take up positions about 12 to 20 miles apart on a pre-arranged patrol line in the gap. No convoy could pass through this patrol line without being seen, provided the line was complete. This virtual blockade was sustained by'milch cow'U-boats, as they were called, which kept the pack supplied with the munitions of war, stores and fuel.

A sharp lookout on the surfacewas kept bythe U-boats until a convoy was sighted. With one sighting the convoy immediately dived and later noted its size, course and speed through its periscope. No torpedo was fired, but when the convoy was out of sight the U-boat surfaced and reported the sighting by wireless telegraphy to hedquarters in France. Headquarters picked up this report and repeated it back to the pack for information, together with instructions as to closing and making contact. It was the duty of theboatwhichsighted the convoy to maintain contact and report the convoy's movements. When a sufficient number of U-boat had been collected, headquarters would order the attack. The U-boats would then get into position, surface after dark and launch an attack on the convoy.

Thepackattack, the new tactic adopted, was devastating attimesand thecrisisoftheBattleof the Atlantic was reached during the foul weather in the early part of 1942. The general situation corresponded closely to the 1917 crisis. That crisis hadbeenmetbytheadoptionof the convoy system, butin 1942 there wasno new method to be tried. Theonly solutionwasmore and morecoastalcommandaircraft of longer range to reduce the sizeofthe black pit, more and more escort vessels, more intensive training of the escort groups and more research in the technique of surface and subsurface surveillance.

Though the crucial month was March 1942, the German efforts began to slacken by April. In May the wolf pack suffered three severe defeats and no further attack developed until September when the Germans tried their newacoustichoming torpedo. These torpedoes inflicted severe damage on the escorts but didnot overwhelm them. Theconvoy was unharmed and the pack suffered considerable loss. This was the turning point of the Battle of the Atlantic for the Germans found their losses too heavy and withdrew their U-boats for installing better equipment and more effective weapons.

There had notbeena single sinking in theNorth Atlantic foranumber of months in early 1943. Teamwork had beaten back the wolf-packattack. As soon as it was certain that the packs had been cleared from that area, Britain turned to the task of sealing off the Bay of Biscay, to prevent their assembling in the North Atlantic again. The support groups and the majorityofthe Eastern strength of coastal command were switched over to present a strong barrier against the ingress of the U-boats from the Bay. The acquisition of a new air base in the Azores in 1943 greatly assisted in this, as the Allies thereby obtained full air cover right across the Atlantic. The offensive was now in the hands of the allis, but this 'flooding of the Bay' was not easy. Coastal command was principally concerned close inshore while the surface forces operated farther out, but the U-boats were now provided with strong anti-aircraft armament and, acting in groups of four to provide mutual support, provided tough opposition to avoid attacks.

The U-boats were able to counter the 'flooding of the Bay' temporarily in 1944 because of the invention of the schnorkel, which enabled them to remain constantly submerged and rendered them almost impossible to detect by radar. The ASDIC had once more to be depended on. Convoy battles flared up again, but the U-boats sustained heavy losses and inMarch they were withdrawn in order to prepare for the next major offensive, the Allied invasion.

There had meanwhile been a new development - a human torpedo had been invented in Italy which could be navigated by a crew of two men seated astride its hull and by means of which they could secure explosive charges under the bottom of a ship at anchor. Several of these craft were ready in August 1941 and, despite the neutrality of Spain, Italy arranged a depot ship off Algeciras from which these craft could attack ships at anchor off Gibraltar. These intrepid men succeeded inlaunching anew form of warfare by successfully damaging 14 merchant ships within a short span of time.

For its capital ships Germany had also prepared almost inaccessible bases many miles up the Norwegian fiords. In recesses protected from submarines by patrols, mine-fields and lines of antisubmarine and antitor-pedo nets, berths hadbeen prepared under overhangingdiffs surrounded by high mountains, which rendered the ships immune from bombing attacks byaircraft. In three such berths, the *Tirpitz, Scharnhorst* and *Lutzow* lay secure and able to slip out when required. Inorder to deal with them, Great Britain devised, with the utmost secrecy, a midget submarine able to pass under nets and lay powerful explosive charges under the bottom ofa ship at anchor. Special crews were trained to manthesecraftandit was intended to make an attack on the ships early in 1943 with a force of six boats, but the boats and crews could not be got ready in time and the operation was postponed until the autumn. The period September 20-25 was considerd favourable as regards durationof darkness and moonlight, and September 20 was selected as D-day. A photographic unit in Mur-mansk had already procured full details of German dispositions and net defences.

The six boats set out on September 11, 1943, each in tow of a submarine, three to attack *theTirpitz,* two for the *Scharnhorst* and one for the *Lutzow.* It was a tow of about 1,200 miles at eight to ten knots' speed, with frequent stops for ventilation, etc., and occupied ten days. Bad weather was encountered and several tow ropes were broken. One boat was lost and one had to be scuttled, but the remaining four arrived duly at the rendezvous and the tows were cast off. Because of defects, one of the submarines had to abandon the attack. It was the only one that returned, but it brought back valuable information. Of the remainingthree which carried out their attack on the *Tirpitz,* one was sunk by gunfire or depth charges before it got inside the nets; the other two, after hair-raising experiences, placed their charges under the ship and with great difficulty managed to get back outside the nets before the explosions. They were sunk by gunfire when they came to the surface, but their charges exploded under the *Tirpitz* and damaged it so severely that it was unable to take any further part in the War. The crew of four of one boat was rescued and made prisoner, as were thecaptain and the second^ in command ofthe other. The achievements were great enough though losses had been heavy.

The great Allied landings in Europe and Africa were not affected by the U-boats due to the absolute secrecy maintained by the Allies as to time and place selected, the dissemination of misleading information and the strong antisubmarine patrols protecting the convoys. Before the Normandy landing, Germany's concentration of U-boats in the channel ports was neutralised by the combined Anglo-American forces with an effective air and naval offensive.

The Battle of the Atlantic was won by the Allies by a narrow margin. This was mainly due to their success in keeping just ahead of Germany in scientific researchand invention, perfect co-operation betweentheairand surface forces as a result of combined training, their long-range shore-based aircraft which Admiral Karl Doenitz acknowledged to be the most deadly threat to the U-boats, the intensive training of convoy escorts, and the dogged determination of the merchant navy and the escorting forces to defy all threats from U-boats.

While the crippling Pearl Harbour raid in December 1941 placed the US naval forces on the defensive, a vigorous and determined offensive campaign against lapanwasimmediately commenced by US submarines. The effectiveness of this underwater war is indicated in the final compilation of Japanese naval and merchant marine losses, which shows that US submarines accounted for more than half the tonna ge destroyed. The nature of operations in the Pacific made the submarine a valuable weapon, both strategically and tactically. While the Europeanconflictwas a ground and air war with naval support, the war against Japan was primarily a naval war, with ground and air support.

The United States naval strategy was from the very beginning based on two important factors in the Japanese economy - the empire was dependent on wartime operations and Japanese shipyards were not able to turn out sufficient shipping to bring in such raw materials from South East Asia and other regions and at the same time carry combat supplies to its increasingly numerous and distant points of naval and military operations across the Pacific. Accordingly, US submarines concentrated their attention on sinking ships so as to stop seaborne movement of Japanese supplies and reduce its merchant marine.

Pearl Habour was the principal US submarine base in the Pacific and the submarine fleet there was fortunately undamaged in the Japanese raid. With the Asiatic fleet, based in the Philippine Islands, was a smaller force of submarines. During the Japanese advance through the Dutch East Indies and the Southwest Pacific islands, submarines from both the Asiatic fleet (reorganised early in 1942 as the 7th fleet and based at the Australian ports of Brisbane and Fremantle) and the Pacific fleet spread across the entire theatreof operations, takingan early toll of Japanese shipping. AfterGuam was retaken in August 1944, the Pacific fleet submarines operated out of that base for the rest of the War.US submarines offered support to Allied forces in the South-West Pacific area, delaying the Japanese advance wherever possible and interrupting their lines of communication. Operating far beyond the effective range of surface or aerial support, they carried their determined attacks deep into Japanese home waters. The very knowledge of their presence in areas under exclusive Japanese domination had the effect of slowing up Japan's operations, while their persistent attacks on

sea lanes brought a rising score of shipping losses which not only reduced the Japanese merchant marine but also interrupted the supply of raw materials to their industry and badly needed supplies to their combat forces. Submarines of the US Navy accounted for 580,390 tons of Japanese shipping during the firstyearofthewarbysinkingl34navaland merchant ships. In the second year, 1943, the score went up to 284 sinkings for a total of 1,341,968 tons. By this time the US submarine building programme was in full swing and in 1944 US submarines sent to the bottom an armada of 492 ships with a total of 2,387,780 tons. This figure does not include merchant ships of less than 1,000 tons, hundreds of which - smaller vessels such as junks, schooners and barges - were destroyed *by* gunfire from surfaced submarines. And with the toll of sinkings mounting, the supply lines to the Japanese ships and shore bases became increasingly difficult to sustain. The US submarines had so depleted the Japanese fleets by 1945 that they managed to sink only 133 ships for a total of 469,872 tons before the war ended. Japanese shipping was hard hit and what was left was confined chiefly to Asiatic coastal waters and the protected reaches of theJapanSea. At the time of the Okinawa landings, US submarines had completely stopped Japanese sea traffic to the East Indies and Indo-China and in the next month they commenced hunting down the last remnants of Japanese sea power in the Sea of Japan and adjoining sea areas.

In the Pacific theatre, the submarine war was..luinly directed against supply ships (tankers, cargo ships, transports, etc.) but the US submarines went after bigger game whenever possible and sank a total of 189 combat vessels, including one battleship, four carriers, four escort carriers, three heavy cruisers, nine light cruisers and 23 submarines. The operations in the Pacific also made it clear that while a submarine is always a hunter, the tactical situation frequently made the submarine the object of a determined hunt. Forty-six US submarines were lost in such attacks but they never accepted the role of the hunted. They continued to be ever on the offensive and, in addition to the ships previously mentioned, they succeeded in sinking 43 Japanese destroyers, the principal sub-hunters, as well as 60 other escort vessels also employed in antisubmarine warfare. Japanese forces were often hardpressed for sufficient escort craft to ensure adequate protection to their own shipping as a result of this offensive.

While US submarines were patrolling various strategic areas in their hunt for Japanese shipping, others were employed in operations more closely connected with the usual concept of navalwarfare. In the Battleof Midway in June 1942, submarines assigned to Task Force 17 served as scouts to report the advance of the Japanese fleets, and the *Nautilus* and *Argonaut* landed marine raiders in the Gilbert Islands at Makin.

Submarines in the North Pacific operated with Task Force 8 in repelling Japanese reinforcements for their Aleutian garrisons in the summer of 1942; the *Grunion* and *S~27* were lost in the Battle of the Philippine Sea in June 1944 which was partly a result of the fact that submarines shadowing the Japanese fleet were able to give Admiral Raymond A. Spruance advance warning of this thrust into the central Philippine area. In this battle, the *Albacore* and the *Cavalla* sank the Japanese carriers Tfli7/oandS//ofcflfcwasaresultof which, for the rest of the war, the US navy had terminated the effective use of Japanese carrier aviation.

The Ba ttle for Ley te Gulf in October 1944 saw US submarines succeed-inginsurprising the heavy first diversion attack force of the Japanese fleet; the *Dace* sank the heavy cruiser *Maya* and the *Darter* sank another, *Atago,* while a third of the six cruisers assigned to that force was badly damaged. The *Darter* was grounded during this engagement and destroyed by US forces later.

The tasks assigned to US submarines during the war included reconnaissance, rescue, supply and lifeguard missions. Submarine reconnaissance could be made in waters where other vessels dared not go. Submarine rescue was effective for the same reason; the final stage of General Douglas MacArthur's escape from the Philippine Islands before the fall of Corregidor was made by submarine. A valuable cargo of gold was likewise removed from the Philippines shortly before the Japanese invasion of the islands.

Submarines were used to supply Allied forces in the Philippines and Netherlands Indies, both before and after the Japanese occupation. Vital medical supplies were taken into Corregidor by submarines before the fall of that fortress, and various guerrilla forces in the islands were supplied with arms and other munitions of war.

Rescue operations atsea by submarines commenced on a minor scale, with the occasional chance rescue of the survivors of a ditched plane. As both air corps and navy carrier strikes against the Japanese increased in strength, the problem of rescuing personnel of planes downed in enemy territory became increasingly important and submarine rescue vessels were included in theplans forsuchattacks. Inonesuch assignment, during a raidonTruk, the *Tang* picked up 22 airmen. Inall, morethan5G0aviators were thus saved from perishing at sea or being captured by the Japane se.

Submarines were also used for mine-laying, charting dangerous or little-known waters and even raids on Japanese soil. Volunteers from the *Barb* once paddled ashore in rubber boats to blow up a Japanese train, and this submarine, as well as others, created havoc and destruction along Japanese coastlines by gun and rocket bombardment of ports and installa tions including factories and refineries.

During the Pacific campaign, the antisubmarinephasecommenced on December 10,1941, when navy carrier planes sank the first Japanese submarine of the war and, incidentally, the first naval vessel lost by the Japanese to any power. Approximately 120 more Japanese submarines were to be sunk by US naval ships and aircraft during the War and on August 14, 1945, a US subm arine got the last Japanese submarine and last major Japanese naval vessel to be sunk.

Destroyers and their new World War II offspring, the destroyer escorts, were the principal participants in the role of submarine sinkers. With *SONAR* and depth charges, later augmented by hedgehogs (much smaller but powerful explosive charges dropped in greater numbers than was possible with depth charges), these craft constantly improved their technique of hunting and sinking submarines and were mostly responsible for the score of 63 submarines sunk by US surface ships.

The hedgehogs' main advantage was that, unless they actually hit **a** submarine, they did not explode, whereas the depth charges went off at **a** predetermined depth and the resulting underwater disturbance hampered further tracking of the target if a hit had not been scored.

The principal submarine killers, i.e., the destroyers and escorts, usually hunted in groups, with one or more ships tracking the submarine *by SONAR* while another followed a course plotted to intersect the submarine's track, at which point an attack wa. made. In such operations, the destroyer escort *England* was credited with sinking six submarines within **a** period of two weeks. US submarines were also successful in tracking undersea craft with sonar and sinking them with torpedoes. A total of23 submarines went to the bottom as a result of attack by US underwater craft; the *Batfish* was credited with sinking three submarines within a four-day span.

Submarines usually operated alone and most attacks on them came when submerged and hence a submarine's sinking generally resulted in the loss of the entire crew. The *Darter, S-39, S-36* and *5-27* were stranded and **all** on board saved; the *Sealion* was bombed butlaterdestroyed by her own crew with a loss of only five men; the badly damaged *Perch* had to be abandoned by her crew, who were captured and imprisoned. In varying numbers, survivors of the *Grenadier, Sculpin, Tang, Tullibee* and *S-44* were also taken prisoner by the Japanese. The *Tang* was destroyed by one of her own torpedoes which boomeranged. In the total of 52 submarines lost by the US in wartime operations, 374 officers and 3,131 men died.

No account of submarine warfare in the Pacific could be complete without reference to the part played by British and Dutch East Indies submarines; about 15 of the latter alone participated in the hopeless but heroic campaign against superior Japanese forces in the early months of the war, with heavy losses. Dutch submarines were credited with the first submarine kills of both Japanese naval and merchant vessels. In the south-west Pacific area, approximately 60 Japanese vessels were sunk by Allied submarines.

During World War II, the number of Allied merchant ships sunk by the U-boats rose from 95 during the last five months of 1939 to 822 inl940, 1411 in 1941,1570 in 1942 and then declined to 597 in 1943^ 205 in 1944 and 97 during the first five months of 1945. The naval vessels lost during the period were two battleships, five aircraft carriers, five cruisers, 34 destroyers, three submarines, 37 frigates, sloops and corvettes and 21 vessels of other types. Germany lostnine U-boats in 1939,22 in 1940,35 in 1941,86 in 1942, 237inl943, 241inl944andl53inl945. Thus the Germans lost a total of 783 U-boats, an alarmingly highnumberbut sank 4,797 Allied merchant ships and 107 naval vessels.

Further Ascendancy **of the Submarine**

Just as had happened during the First World War, the U-boats had once again come very close to winning the Second World War but were only narrowly defeated by two factors - installation of radars in May 1943 in ships and aircraft for the first time for surveillance at sea and the spurt in American shipbuilding activities.

In the Pacific theatre, the American submarine campaign against Japanese commerce had been extremely effective; it had defeated the Japanese convoy system and, aided by aircraft,had brought her commerce to a standstill. This was probably the most important single factor in the victory over Japan and at least equal inimportance to the great aircraft carrier and amphibious advance across the Pacific.

The American submarines had also sunk approximately one-third of thewarships of thejapanese Navyandalthoughtheywereonly second in effectiveness to carrier and shore-based aircraft, their role had far greater significance than the American battle fleet's. The British experience with their submarines during World War II was similar, especially in areas where surface forces were unable to operate because of enemy air power, notably in the Mediterranean.

Thus thesubmarine ended World Warll witha greatly enhanced reputation and proved itself to bemore important than abattle fleet and second only to the aircraft carrier as a warship. One aspect of its capabilities that stood out was that it was able to operate in the face of first-line enemy air power and so was now without doubt a weapon of the stronger as well as the weaker sea power.

Secondly, although it had been eventually defeated in the Atlantic as a commerce raider, the submarine confirmed that it was still apotentially war-winning weapon. Not only had it been victorious in the Pacific but the antisubmarine measures which had defeated it in the Atlantic only countered it as a submersible torpedo and it was realised that most of them would be ineffective against a true submarine which operated submerged all the time.

To quote Vice Admiral Sir Arthur Hezlet who commanded six British submarines during World War II and was Flag Officer Submarines of the Royal Navy and later Flag Officer Scotland and Northern Island:

'Thenew German types of submarine of greatly improved submerged performance being produced at the end of the War therefore meant that the U-boat campaign against commerce had really only been held and not defeated.'

If the Germans had been able to build the schnorkel-fitted, high-speed underwater craft which they had perfected by 1944 and on which even today's conventional submarines are largely based, a couple of years earlier, and in large enough numbers, they could have won the w^r at sea during World War II.

The submarinecameintothelimelightduring theearlier years of this century and gained considerable notoriety by wreaking havoc upon Allied merchant and naval shipping during World War I. Germany again demonstrated the lethal power of submarines and their supremacy over surface forces during World War II when, the depredations of the U-boat against merchant ships carrying Allied personnel and munitions of war in the Atlantic almost brought the Allies to their knees.

A careful assessment of the versatility of this underwater craft can be judged from the following aspects of its capabilities. A submarine can operate submerged in waters which is under the control of a hostile naval power, it can mine entrances to enemy harbours, passages, straits and waterways, it can attack shipping entering or leaving enemyports, it can sink enemy naval or merchant vessels while remaining submerged at a place of its own choice irrespective of the sphere of influence on the surface. It cannot be identified unless it is captured, which is most unlikely, or destroyed when the items in the flotsam caused by its debris are picked up by the attackers. Detecting and taking effective countermea-sures against a lurking submarine in aseaarea,

largeor small, evenbya predominantly superior surface fleet is extremely difficult even today despite all the technological and tactical advances made.

Another sphere of a submarine's dominance is that of the detection and destruction of submerged enemy submarines, especially those hiding below the thermal layer-alayerofwaterat varying depths from the sea surface in tropical waters where the interface between the layer and the water above reflects the sound pulses emitted by ships' sonar sets and these layers are, therefore, a safe haven for a submarine hiding from an attacking surface fleet. This happens because the temperature gradient, i.e.,the fall in the temperature of sea water with increasing depth reverses at the interface and the temperature starts rising. In oceanographic parlance, this phenomenon is known as 'temperature inversion' and is quite common in the tropical and subtropical regions. Since the sound pulses emitted by the ASDIC sets or the latter-day sonar sets cannot penetrate the thermal layers and undergoes total reflection, it is only a submarine which can dive below the interface, locate the enemy submarines lurking in the thermal layer and destroy them.

The submarine, however, has a few drawbacks compared to a surface ship. Firstly, the submarine has to essentially remain submerged in the tactical area to conceal herself and hence cannot have as detailed or as wide a view of its surroundings as would be available from the deck of a ship. Secondly, by itself, it is not as effective as a visible deterrent as surface ships for such tasks as blockading harbours, straits or waterways - though it could supplement a surface task force in that role especially when the enemy is also operating submarines in a defensive roleorhasair superiorityoverthearea.Thirdly,forthe same reason, i.e., for not being a sufficiently effective visible deterrent, it is not very effective for what is known as gunboat diplomacy - flexing of naval muscles to overawe an inferior naval power into submission.

These drawbacks notwithstanding and despite the overwhelming superiority of today's'nukes' - submarines with nuclear propulsion and nuclear weapons which virtually have unlimited endurance, extreme lethality and a hitting range of tens of thousand miles, the conventional submarine, which will continue to fulfil the tactical missions for many decades, is here to stay.

Admiral S.N. Kohli, formerly the Chief of the Naval Staff, wrote in 1978:

> Interestingly, the advent of the nuclear submarine has itself given a fresh lease of life to modern conventional submarines, for various reasons. One is the fantastic cost of nuclear submarines; it is believed that each of the *Trident* class will cost approximately Rs 1,000 crores. Another is the relative noisiness of the nuclear submarine as its vast bulk is driven at high speeds by powerful steam turbines. Modern sensors fitted in ships and aircraft make underwater noise detectable at considerable distance.
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> The conventional submarine is regarded as a good weapon not only to attack nuclear submarines within its endurance zone but also to attack and destroy other conventional submarines. Because of its relatively slower speed and motor-driven propulsion, it is comparatively silent. Further, it has benefited from the same advances in qualities of steel, sensors, and weapons that have made the nuclear submarine a

formidable foe. Yet another virtue rediscovered in the conventionals is their compact small size, whichmake them extremely difficult to locate and attack. Thus, the conventional submarine has acquired a new status in the antisubmarine role, particularly when used in combination with other antisubmarine forces such as surface ships, helicopters, and fixed wing aircraft.